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French engineers working a military searchlight in the Champagne district.

WATCHING THE ENEMY FROM THE FIGHTING LINE.—[See page 88.]

Is the Organism a Thermodynamic Mechanism—I*

A Consideration of Certain Organic and Inorganic Systems in Relation to Physical Laws

By James Johnstone, D.Sc., University, Liverpool

LET us consider the chemical reactions represented by the following equations:

(1) $CH_4 + 2O_2 = CO_2 + 2OH_2 +$ 213,800 gram-calories;
Methane

(2) HCl, aq. + NaOH, aq. = NaCl, aq. + OH_2 + 13,700 grm.-cal.;

(3) $2C_2H_2 + 5O_2 = 4CO_2 + 2OH_2 +$ 310,000 grm.-cal.
Acetylene

(4) $CS_2 = C + S_2 +$ 28,700 grm.-cal.
Carbon disulphide

The first two reactions are typical examples of processes which occur commonly in organic and inorganic systems. The first represents an oxidation, and the second a neutralization. When methane burns completely in oxygen carbon dioxide and water are formed, and a certain quantity of heat is evolved. When very dilute hydrochloric acid is added to very dilute caustic soda a neutral salt, also in dilute solution, is formed. If quantities of each of the reacting substances equal to the molecular weights, in grams, represented by the formulæ take part in the chemical changes, quantities of heat represented by the numbers given on the right-hand sides of the equations are evolved. The reactions are *exothermic*. In most chemical changes the "intrinsic energy" contained in the substances before they react is greater than is the intrinsic energy contained in the products formed by the reaction, and the balance of energy appears as evolved heat. The 213,800 gram-calories of equation (1) are the heat of combustion of a gram-molecular weight of methane; and the 13,700 gram-calories of equation (2) are the heat of neutralization of gram-molecular weights of hydrochloric acid and sodium hydrate.

Equations (3) and (4) represent also exothermic reactions. In the first of these acetylene burns completely in oxygen; and in the second one carbon disulphide is decomposed into its elements. When acetylene burns in this way 310,000 gram-calories of heat are evolved; and when carbon disulphide is decomposed completely 28,700 gram-calories are evolved. Now, if we calculate, from known data, the heats of combustion of the carbon and hydrogen contained in a gram-molecular weight of acetylene we shall find that it is only 256,900 gram-calories; therefore the balance of 53,100 gram-calories must be absorbed when carbon and hydrogen are synthesized as acetylene. Also when carbon and sulphur are synthesized to form carbon disulphide 28,700 gram-calories, the heat of dissociation of the compound must also be absorbed. These reactions, the combination of carbon and hydrogen to form acetylene, and carbon and sulphur to form carbon disulphide, are therefore *endothermic* reactions. In them the intrinsic energy of the final product is greater than the intrinsic energy of the initial substances.

The difference between the two kinds of chemical change—exothermic and endothermic changes—is fundamental. Nearly all substances which react with each other do so with the evolution of heat. A few reactions occur in which heat is neither evolved nor absorbed, but these are of an altogether special kind. A few reactions also occur in which heat is absorbed. These, also, are special chemical changes; they are not numerous; and the products resulting from them are unstable as a rule.

Considering further the above reactions two things are to be noted. First, exothermic reactions occur *of themselves*. Immediately caustic soda is added to hydrochloric acid neutralization begins. Methane and oxygen do not react at ordinary temperatures (or they react "infinitely slowly") but an infinitesimal amount of energy starts the reaction which then proceeds until it has been completed. Endothermic reactions, on the contrary, do not occur of themselves: carbon and hydrogen will not react by themselves to form acetylene, nor will carbon and sulphur to form carbon disulphide. These reactions will not occur, as does the explosion of a methane-oxygen mixture, when an infinitesimal "stimulus" is applied. *In order that they may take place a compensatory energy-transformation must be set up*, and in this compensating reaction an amount of energy equal to that absorbed in the endothermic change is supplied. I have emphasized the above sentence in order that the reader may appreciate the importance that it has for our later discussion.

The second thing to notice is that the equations show that chemical reactions are *directed changes*. In all exothermic reactions, that is, in the vast majority, heat is evolved. If the reaction takes place of itself, that is, apart from intelligent ordering of the conditions under which it occurs, this heat is dissipated: it is conducted away, or radiated, and it raises the temperature of its physical surroundings to an infinitesimal degree, so that it can no longer be recovered or made use of to produce further transformations. In all physical or chemical changes of this category the heat so produced becomes *unavailable;* and the products of the changes, if they are chemical changes, possess less intrinsic energy than did the original substances. Thinking about chemical changes in general we see, then, that each one that takes place exothermically reduces the probability of the occurrence of further exothermic changes, since in it some part of the available energy of the universe has become unavailable. Every such chemical reaction tends towards stability, since the products are less likely to react with each other, or with other substances, than were the original substances.

The opposite tendency is exhibited by endothermic changes, for in such the products of the reaction possess a greater quantity of intrinsic energy than did the original substances. The reaction tends towards instability, for the substance which is formed endothermically is more likely to react (it is often explosive) than were the substances from which it was formed. In the preparation of an endothermic substance some heat is certainly dissipated, since we cannot avoid the loss of heat by conduction and radiation, and we cannot, as a rule, control perfectly the progress of the reaction. But the general result of the change is that energy remains in the available form, and can be made use of in the production of other energy-transformations.

We may now generalize these statements. All physico-chemical changes whatever, organic or inorganic, exothermic or endothermic, are said to conform to the two laws of thermodynamics. The first law states that the energy of an isolated system is constant, that is, by no conceivable change occurring within the system can the sum of potential and kinetic energy contained in it be diminished or augmented. If we couple the law of conservation of energy with the law of conservation of matter (in modern views the latter is, of course, contained in the former), we arrive at the conclusion that nothing in the universe can be created, nor can anything be destroyed. But the second law of thermodynamics states that something which is characteristic of an isolated physico-chemical system, its sum of entropy, tends continually to become augmented. Our only isolated system is the universe, and the most general statement of the second law is that the sum of entropy of the universe tends continually to a maximum.

We cannot discuss here the shadowy mathematical concept called entropy, but we may state the second law (partially, but correctly for our purpose) in saying that something is irretrievably destroyed in every physico-chemical reaction that occurs. This something is available energy. Energy, potential or kinetic, that is, energy of position or the energy of motion of entities possessing mass, which can be made use of in producing or setting up transformations, or natural phenomena, is available energy. The heat energy of one part of a system which is at a higher temperature than another part, for instance, the energy of steam in a boiler in relation to the energy of the condenser water is available. Energy which cannot be utilized to set up transformations—to do work—is unavailable; such is, for instance, the heat energy of the ocean in relation to the engines of a ship traversing it. In order that some of the energy of a system may be available some part of it must be at a higher potential than another part. If there are no differences of potential the energy is unavailable. Now, in all natural changes, or phenomena, or energy-transformations, there is an ever-present tendency for some fraction of the total energy manifested in the change to become converted into low-temperature heat. Such heat becomes conducted or radiated into the earth or into space, becomes uniformly diffused, and so becomes unavailable. This occurs in endothermic and exothermic processes. In the imaginary world of mathematical physics natural phenomena may occur in systems with perfectly elastic or perfectly rigid parts, where there is no friction, and where heat is either perfectly conducted or perfectly insulated. But in the real world all natural processes are such as involve friction and loss of heat. In all of them some energy becomes unavailable. All of them are *irreversible* processes, that is, processes which cannot be retraced. With every such irreversible process some part of the available energy of the universe becomes unavailable. With every natural phenomenon that occurs the number of phenomena that may occur in the future becomes appreciably less. "Every irreversible transformation leaves an indelible imprint *somewhere or other* on the progress of events in the universe considered as a whole."

Thus there is a *tendency or direction* in the progress of inorganic happening. Energy is continually being degraded, continually passes from the available into the unavailable form. With every such transformation the number of things that may happen in our universe in the future becomes less. The universe tends toward a limit which is the cessation of all phenomena—universal physical death. There is nothing fanciful or metaphysical in this conclusion. It is a sound deduction from the results of physical science. It is the plain outcome of our experience.

And yet it is perfectly clear that we cannot extend it, *à priori*, to the universe as a whole. We must extend universally the law of the conservation of energy—it is unthinkable that it cannot apply to all that exists. If we imagine, literally, that the sum of available energy in the universe was infinite, then the fall of available energy is asymptotic to time considered as the independent variable. But we must also regard time as infinite, that is, we must think of the universe as having, literally, no beginning and no end. Obviously, we are only juggling with words in these statements. Infinite time is really time that has as great a duration as we please to conceive. Then in the lapses of duration that lie in the past of our universe the limit to the fall of available energy must have been attained if the second law be universally true. But we look out upon a universe which is still the theatre of inorganic phenomena. The second law cannot, then, be universally true, like the first law is universally true. But it *is* true of all that comes within our experience.

Thus we come to an *impasse*, for two aspects of our experience seem to be flatly contradictory to each other. On the one hand the results of experimental physics show us a universe in which there is a progressive degradation of energy, that is, an energetic system which had a beginning and will come to an end. On the other hand experience also shows us a universe in which natural phenomena still occur, and for which we can postulate any past duration, however great. Now there appears to be only one way out from this deadlock; somewhere or other in the universe *there must be a restoration of available energy*. This is the explanation suggested by Boltzmann, and we may usefully consider it here, since it suggests at once a manner of regarding the activities of the organism which indicates that a theory of life may, after all, be possible.

Let us consider, then, a volume of a "perfect" gas equal to, say, one tenth of a liter. Let this gas be contained in a vessel made of some perfectly non-conducting material, and let the vessel have a partition, also made of non-conducting material, dividing it into two chambers. Let the gas in the two chambers be at unequal temperatures, T_1° and T_2°, T_1° being greater than T_2°. Now let the partition be withdrawn so that the gases mix. In a few minutes thermal equilibrium will be established and the temperature of the mixture will be, everywhere, sensibly the same.

A perfect gas consists of a very large number of molecules moving in straight lines at very high velocities. These molecules incessantly collide with each other, and since they are perfectly elastic no energy is lost in the collisions. They must be moving in every conceivable direction and (within a certain range) at different velocities. But there is, at a definite temperature and pressure, a certain mean molecular velocity toward which the greater number of the molecules approximate. Some are moving at higher, and others at lower velocities than the mean one, and these velocities other than the mean deviate from the later in such a way that they can be represented by a "frequency distribution" with the mode at the mean. For two gases differing only in their temperature the squares of the mean velocities are proportional to the absolute temperatures, that is, $V_1^2 : V_2^2 = T_1^\circ : T_2^\circ$.

Since the molecules of the gas are moving with dif-

* From *Science Progress.*

ferent velocities, and in every conceivable direction, the result of their collisions must be that molecules moving with speeds above the mean will tend, owing to collisions with molecules moving with speeds below the mean, to lose some of their velocity. When the two gases at different temperatures are allowed to mix the molecules of the hotter one will communicate to the molecules of the cooler one some of their velocity of movement. Thus the temperature of the cooler gas must increase while that of the hotter one must decrease. This is a progressive change requiring some time (a matter of minutes). At each momentary phase of the progressive change there is a new distribution of the molecules and of their directions and velocities of movement. Every such phase is, of course, a dynamical consequence of the preceding phase. When thermal equilibrium has been attained the mixture of molecules has a new mean molecular velocity with individual deviations from the mean represented by a new frequency distribution.

Now it can be shown that if, at the moment at which thermal equilibrium is attained, the direction of motion of each molecule were to be reversed, the series of changes through which the mixture had passed would also be reversed. It would gradually become separated into two masses of gas, each of them characterized by its original temperature. Instead of having a gas at uniform temperature in every region we should have a gas separated into two parts, in thermal contact with each other but having different temperatures. The progressive change from two masses of gas at unequal temperatures to one mass of gas at uniform temperature would be reversed. The series of momentary phases leading from inequality to equality of temperature would be exactly followed, *but in inverse order.*

It is important to note here that the second law of thermodynamics would apparently be "violated." Heat would flow, of itself, from a body at low, to a body at high temperature. But if this were to happen, perpetual motion would be possible, whereas we know (at least it is our experience) that it is impossible. Therefore we must conclude that heat cannot flow, of itself, from a body at lower to another body at higher temperature, and we seem to be justified in concluding that this imaginary simultaneous reversal of motion of all the molecules of a gas cannot take place.

Yet it may conceivably take place. At any instant many of the molecules in a deciliter of gas must be approaching each other in the same straight line, and with the same velocity. As the result of such collisions the direction of motion of these molecules must be reversed, the magnitude of their motions remaining unchanged. The number of such molecules as collide "end on" is continually changing; sometimes there are relatively many, sometimes few. The probability of any fraction of all the molecules so colliding can be calculated, and also the probability that *all* the molecules should collide end on, so leading to a reversal of the physical history of the gas. The calculation has been made by Boltzmann. It is possible that this simultaneous reversal of motion of all the molecules in a deciliter of perfect gas may occur, but in order to witness it we might have to observe the gas for a lapse of time represented (in centuries) by unity followed by a thousand millions of ciphers! The chance is thus very small. It is about equal to the chance that all the houses in London might catch fire, independently of each other, on the same day, or that all the men in London might commit suicide, independently of each other, on the same day. An insurance office would certainly disregard such risks. They would say that it was "practically impossible." So we must say that it is "practically impossible" that heat should flow, of itself, from a colder to a hotter body; that perpetual motion is a practical impossibility; and that it is also practically impossible that the second law of thermodynamics does not apply to all physical and chemical transformations. We say, therefore, that all natural phenomena have the same tendency—toward degradation of energy, or augmentation of entropy—and much of our power of so ordering naturally occurring events, or of forecasting future events, depends on our confident assumption that this tendency will continue to hold true. It is *almost* certain that the second law of thermodynamics will be valid in all our future experience as it has been valid in all our past.

"Almost certain," we say, but not logically capable of demonstration—not inevitable. The first law—that of conservation—is *à priori* certain, that is, it is unthinkable that it should not be universally true. But the second law is only a probability—a very great probability if we like. Now let us regard the deciliter of gas of our example as a "model," in a kind of way, of the universe. Like the universe we may describe it as a "collection of isolated mass points, devoid of rotatory inertia, moving in accordance with Newton's laws, and attracting or repelling each other with forces which are continuous or discontinuous functions of the distance between them." If, then, we extend the general conclusions deducible from the kinetic gas-theory to the Universe itself, we might consider whether heat may flow, of itself, from colder to hotter regions—in general, whether there may not be, somewhere, a restoration of available energy. The possible form of such a speculative process would depend on the cosmology we adopt; obviously we cannot consider it in detail now. But clearly this restoration of available energy may occur in the universe, and the probability that it does so occur is of the same order as that in Boltzmann's estimate.

The probability is, as we have seen, unimaginably small. But the universe is as unimaginably great. What do we mean by saying that the universe has infinite extension and duration? We do not mean that it has, literally, no boundaries; nor that it had no beginning and will have no end. To say as much is to play with pseudo-ideas. When we say that the universe has infinite extension we mean that no matter how great, in finite numbers, it may be conceived to be, it can still be conceived as greater; and so also with its duration. That is to say, we can make the universe as big as we like, or as old as we like, while still regarding the dimensions we ascribe to it as such as are capable of mathematical treatment. Its extension and duration are "infinite" in the sense that we speak of infinitesimally small magnitudes in the theory of the differential calculus. The radius of the earth, the distance of the earth from the nearest fixed star, and its distance to stars of no parallax are to be regarded as infinitesimals of the $(n-1)$st, $(n-2)$nd, and $(n-3)$rd orders. The duration of a man's life, the age of the habitable earth, the age of the solar system, may also be so regarded. It does not matter now that the probability of a restorative of available energy is incredibly small. We can suppose the duration of the universe to be as much greater as we wish.

The universe that we know is the material universe *in which there are energy-transformations.* We may regard it as an infinitesimally small part of all that exists—the entire universe, let us say, in short. Its duration we may also regard as an infinitesimally small part of the duration of the entire universe. The latter is physically dead: the sum of its entropy has attained its maximum value. But here and there in it are regions of the magnitude of our known stellar universe—individual universes, Boltzmann calls them—but infinitesimal in their extension when compared with the entire universe. In these individual universes, for moments when compared with the duration of the entire universe, but for eternal eras (Aeonen) when compared with a human lifetime, the second law of thermodynamics becomes reversed, just as it does in our imaginary deciliter of gas. Physical inertia is "normal," that is, it is the most probable condition of a dynamical system in the general sense. But in small regions of the entire universe, and for infinitesimal periods of duration, the improbable condition may obtain. It does occur in regions of a deciliter of gas, if we take these regions small enough. Here and there there are certainly small groups of molecules, in which, for a very small time, the mean linear velocity, and therefore the temperature, is greater than in adjacent regions.

Such a universe, one in which there was physical activity, as there is in our universe, would be passing from an improbable toward a more probable phase. The most probable phase would be that in which entropy had attained its maximum value; the least probable phase would be that of zero entropy. The phase of physical activity would be preceded by a phase of restoration of available energy, that is, a passage from the most probable to the least probable condition. Time would have a double sign. The passage from the improbable toward the probable conditions would occur in *our* time, that is, from the past to the future. But in the period of restoration of available energy the scale of time would be reversed, and the passage from the most probable to the least probable phase would occur in time which moved from the future back into the past. Conscious organisms in such a phase of an individual universe would possess knowledge of the future but not of the past.

(*To be concluded.*)

Limits of Experimental Investigation

By Our Berlin Correspondent

THE problem as to where the limits accessible to experimental investigation are reached has ever been one appealing to the human mind. While it would be permature to answer the question in an absolute manner, assigning to scientific work a boundary never to be exceeded, the limits corresponding to the present state of science can be ascertained with a high degree of accuracy.

The lowest temperature obtainable by artificial means, until 20 years ago, was —87 deg. Cent., liquid carbonic acid being used for its production. When then Prof. Linde, by the construction of his refrigerating machine, opened up new fields to cold storage scientists succeeded in working at temperatures as low as —190 to —200 deg. Cent. Since hydrogen does not boil above a temperature of, say, —253 deg. Cent. the use of this liquefied gas allowed even lower temperatures to be reached, while helium, the boiling point of which lies at —269 deg. Cent., quite recently enabled Dr. Kamerlingh-Onnes nearly to reach the temperature of absolute zero.

As pointed out by Prof. Kurt Arndt, in a lecture held at the Society of German Chemists, the temperature of the electric arc forms a counterpart to this lowest temperature reached by artificial means. It is true that the temperature of the electric arc is anything but uniform, 3,000 to 4,000 deg. Cent. being recorded at some places, while others only show temperatures as low as 1,000 deg. Cent. Whenever constant temperatures are to be used for purposes of scientific investigation, they must therefore be produced by means of electric radiators. Thin nickel wires traversed by electric currents will be sufficient in this connection up to 1,000 degrees, while Heraeus' platinum furnaces are used above this limit, and iridium metal (which, it is true, cannot be drawn out into wires or hammered,) between 1,500 and 2,000 deg. Cent. Since the melting point of tungsten is as high as 3,000 deg. Cent., its use allows even higher temperatures to be reached, though on account of its sensitiveness to atmospheric oxygen, this element must be kept in the vacuum. The highest temperatures (up to 2,700 deg. Cent.) therefore are preferably produced by the aid of carbon resistances, used in connection with several types of electric furnaces.

The most varied instruments are used to gauge the low and high temperatures thus produced. Degrees of cold can be determined with mercury thermometers only as far as —38 deg. Cent., which is the freezing point of mercury. Liquid thermometers, filled with liquids, such as pentane, will suffice down to temperatures of, say, —100 deg. Cent., when pentane becomes plastic. Resistance thermometers, designed by William Siemens (and based on the increasing electrical conductivity of platinum with decreasing temperatures) serve for the measuring of temperatures still lower. The relation between temperature and the resistance of platinum being known, temperatures above —1,000 deg. Cent. can be gaged by this means. Thermo-electric pyrometers (based on the production of electric currents by heating the contact between certain metals and metal alloys) are used in determining temperatures between 500 and 1,500 degrees, while optical pyrometers—in connection with which the surface brightness of incandescent bodies is determined by an optical process—must be resorted to in the case of temperatures even higher than 1,500 degrees. The greater the brightness of an incandescent body, the higher, of course, will be its temperature.

As regards, next, the measuring of time, stop watches will be sufficient for intervals of, say, one-fifth of a second as a minimum. Any more rapid phenomena must be allowed to record themselves of their own accord. In the case, for instance, of explosive phenomena, the pressure of explosion is made to displace a minute mirror, whence a reflected beam of light falls on a revolving drum coated with photographic paper. The displacement of the mirror, as produced by the pressure of explosion, is thus recorded photographically, intervals of, say, 1-50,000 second being gauged in this way.

While ordinary chemical scales, of course, insure an accuracy of 1-10 milligramme, extra-sensitive weighing machines, such as those used in comparing standards of weight, allow differences as small as 1-500 milligramme to be ascertained.

Especially sensitive, however, are the processes used in determining lengths, the interferometer allowing the three-hundredth part of a millionth of a millimeter to be gaged, a length far too small to be conceived by the human mind. The ultra-microscope, finally, enables the one hundred-thousandth part of a millimeter to be visualized in gold solutions.

Owing to the Demands for the by-products of coke ovens in Germany for use in making explosives the production of coke has been very greatly increased; and to create a market for the additional amount of coke the Government is encouraging manufacturers and railways to mix coke with their coal.

High-Speed Printing Telegraph System*

One of the Many Attempts to Solve a Difficult Problem

By Carl Kinsley

THE rate of increase in the amount of business transacted by telegraph has been most marked during the past few years. The extension of the network of telephone wires and their universal use in local business has seemingly stimulated the desire for a formal method of inter-communication which is more rapid than the mails.

The operating companies have responded as fully as they could, with the means available, to the public demand for a more rapid, accurate and inexpensive service. They have carefully tested many systems of telegraphic transmission that have been presented to them. None of the systems, however, have fulfilled all of the requirements for accuracy in the transmission of the messages, rapidity of operation from the receipt of the message to its final delivery, and low cost.

It is impossible to adequately mention in the brief space available the telegraph systems which have already been tried, some of which have by no means been discarded. Among them the following may be of particular interest.

The Rowland multiplex printing telegraph system[1] has enjoyed a limited use in Italy, and was experimentally operated on commercial business for a considerable time in this country. On the basis of eight machines, operating simultaneously over two wires, a speed of 400 words per minute could be obtained.

The Murray printing telegraph[2] was given a commercial test in America in 1900, and later taken to England, where it was developed to a much more perfect state in the laboratories of the British P. O. Department. It has recently been given a month's trial in this country. Used duplex with four machines working on the two-wire circuit, and with eight automatic translators, a speed of 400 words per minute can be reached.

The Baudot printing telegraph[3] has been extensively used in France and India, while recently its use has been spreading to Great Britain, where certain improvements have been added. On the basis of duplex working, and using two wires, 160 words per minute can be transmitted.

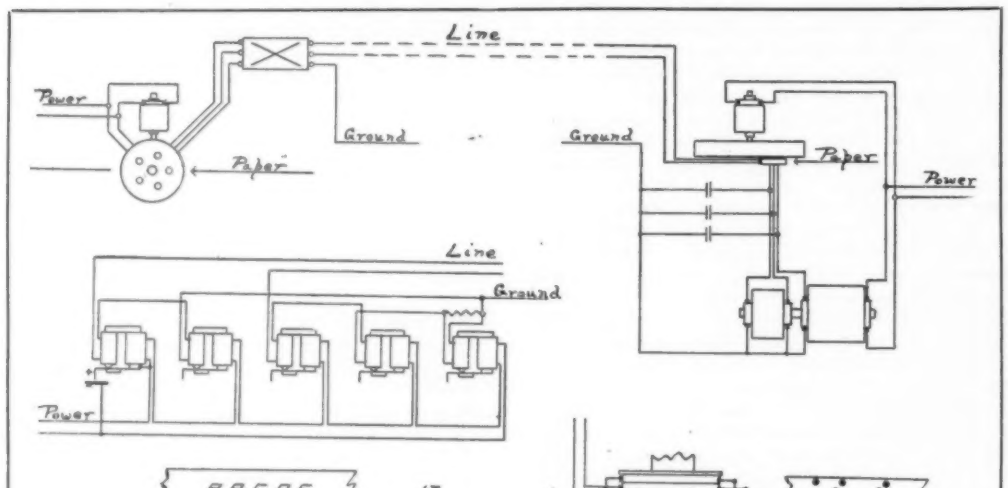

Fig. 1.—Wiring connections, and specimen of transmitting tape.

The Siemens-Halske rapid printing telegraph system[4] has been remodeled from the system developed and extensively tested about 1903, which used a photographic process of recording. In its present form it has been successfully used on certain German lines, and is being tried over three or four different circuits at the present time. It seems to be specially suited for underground cable work as the speed of each instrument is low and the required perfect control of both synchronism and phase of the transmitter and receiver is then not affected by atmospheric conditions. The necessity for an entire absence of disturbance can be comprehended when it is noted that many letters require the operation of seven relays to switch circuits in the through line in preparation for each record. On the basis of duplex working and the use of two wires a speed of 400 words per minute is obtainable. This is only half as fast as the early form which required the developing, fixing, washing, and drying of the record of the receiving message, and thus produced a condition at the receiving end which was considered uncommercial.

The Pollak-Virag writing telegraph system,[5] unlike any of the preceding, does not require synchronism between transmitter and receiver. The received message, however, is photographically recorded on a sheet, which process entails expense and delay in handling the message. It was given an extensive commercial test over German lines and also was exhibited in England and in this country in 1899. On the same basis as that used in the tests of the previous systems the Pollak-Virag telegraph operated at 650 words per minute.

The system about to be described does not employ synchronism between transmitter and receiver, there are no relays used in the operation at either end of the line, only one instrument is employed, and the message is received ready for distribution. On the same basis of computation used in the above systems the speed of operation of the author's printing telegraph is 650 words per minute over a 375-mile (603.5 kilometers) line.

The method employed is direct throughout, and the transmitting and recording parts are capable of such adjustment that the speed of operation is limited only by the speed of the line. The mode of operation is as follows:

By means of a punch, which is connected to a commercial typewriter, a ½ inch (1.27-centimeter) strip of paper is punched with a series of groupings of holes distinctively spaced in five rows, each group representing a letter. The punched strip of paper is then sent through the transmitter so that the holes pass under five wire brushes. Batteries of either polarity are thereby connected between the earth and either one of a pair of conductors. Batteries of different potential can also be used, and in one case that is done, making five different transmitting impulses. Fig. 1 shows the wiring connections, a representative piece of transmitting tape, the printing elements and a section of the record.

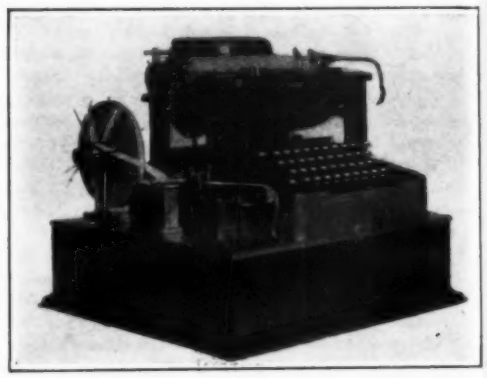

Fig. 2.—Machine for preparing the transmitting tape.

At the receiver there are five elements which are separately controlled, except that No. 3, which needs only the normal current, also operated when the strong current needed to operate No. 5 is received.

The printing is accomplished by subdividing the alphabet into four independent elements and a fifth which, whenever used, accompanies one of the others. These elements then make an autographic record by means of a local battery on a moving sensitized paper whenever they touch the surface. It is merely necessary to have them operated in the proper sequence and with the desired interval in order to obtain any letter or figure of the alphabet.

Fig. 2 shows the punch for preparing the transmitting tape. A commercial typewriter is set on the punch base and the operation of preparing an office copy of the message also punches the transmitting tape. The depression of the digit bar sets the proper punch combination, then closes the circuit of an electromagnet, which completes the operation of punching and spacing the transmitting tape. The tape is then rolled up ready for use on the transmitter. As many punching machines can be used at the same time as may be needed to supply the transmitter with a sufficient number of rolls of prepared messages.

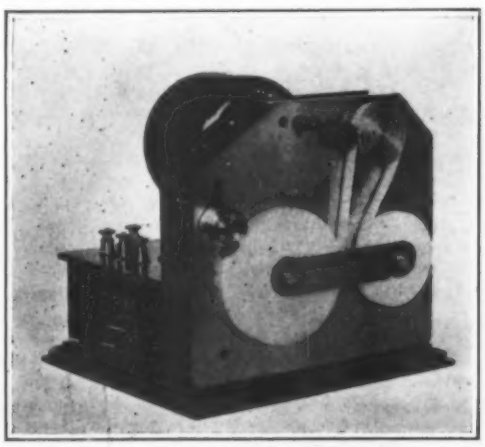

Fig. 3.—The automatic transmitter.

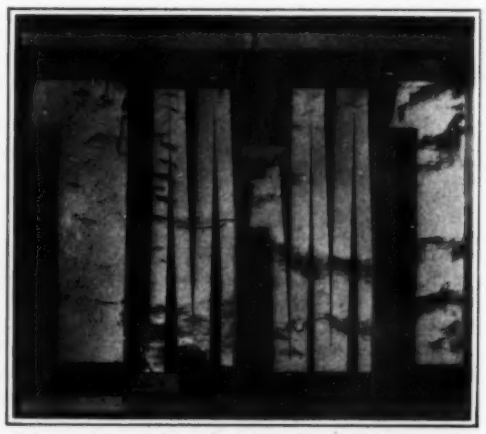

Fig. 4.—Artificial line for testing the system.

* From a paper read at the Annual Convention of the American Institute of Electrical Engineers.

[1] G. Robichon, "Le Telegraphie Rowland," *Journal Telegraphique*, January 25th, 1901, and February 25th, 1901. Potts, "The Rowland Telegraph System," A. I. E. E. Proc., April, 1907.

[2] Vansize; "A New Page Printing Telegraph," A. I. E. E. Proc., January 25th, 1901. Murray, "Practical Aspects of Printing Telegraphy," Inst. Elec. Eng. *Jour.*, vol. 47, page 450, 1911. See also *Electrician*, May 5th and 12th, 1911.

[3] "D'Appareils Baudot," Poulaine and Faivre, Paris, 1906. Williams, "The Baudot Telegraph System in India," *Electrician*, March 22nd, 1907.

[4] Franke, "Der neue Schnelltelegraph der Siemens und Halske," *Elektrotechn. Zeitschr.*, September 25th, October 2nd and 9th, 1913.

[5] "Der Schnelltelegraph von Pollak und Virag," *Elektrotechn. Zeitschr.*, October 11th, 1900. "Recent Improvements of the Pollak-Virag Writing Telegraph," *Electrician*, July 3rd, 1903. "Telegraphie Rapide Systeme Pollak et Virag," *Ecl. Electr.*, January 5th, 1907.

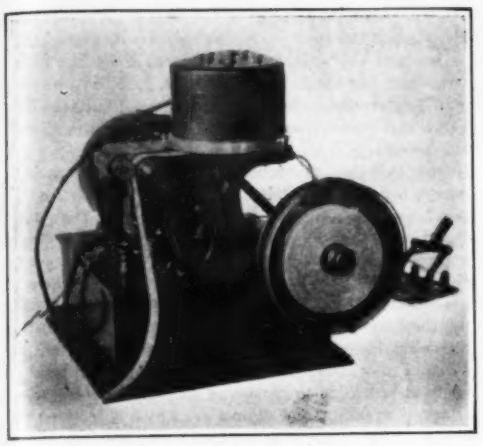

Fig. 5.—The receiver.

Fig. 3 illustrates the automatic transmitter. The roll of paper carrying the message is driven under the wire brushes which drop through the holes and make contact with the underlying rings, five in number. These rings are slowly rotated, driven by the paper friction, so as to insure a continually changing point of contact. No trouble at all has been experienced with faulty contacts. No speed control has yet been used on the driving motor as it has not been found necessary to have any exact speed of transmission.

Fig. 4 shows the method of construction of the artificial line used for testing this system, which needs more than a passing notice. It is made of a great many sections, all connected in series. Each section consists of two tinfoil grids, separated by wax paper with solid tinfoil sheets outside of them, also separated from the grids with waxed paper. The solid sheets are 6½ inches by 9 inches (16.5 centimeters by 22.8 centimeters) and completely cover the grids, which are superimposed. There is thus complete distribution of the capacity and resistance of the two parts of the circuit with respect to each other as well as with respect to the ground, while each section is shielded from the neighboring sections. The total capacity from either line to ground, measured with an a-c. pure sine wave of 120 periods per second, is 4.05 microfarads. The total resistance of each line is 747 ohms, while the leakage resistance due to dielectric absorption is 2×10^6 ohms. There is no appreciable self-induction. On the basis of an open wire circuit having a conductor 0.43 centimeter in diameter, the capacity and resistance relation would make the artificial line equivalent to a circuit 375 miles (603.5 kilometers) long.* Since the open wire line has also distributed self-induction, the current at the distant end of the actual line would be greater than that at the end of the artificial line, if the impressed electromotive force were the same. The oscillograph record shown in Fig. 8 gives the current distortion, due to the long line.

Fig. 5 shows the receiver of the author's printing telegraph system and Fig. 6 is another view of it with the head lifted from the tape to display the printing elements. It uses two local circuits; one energizes the magnetic circuit which normally holds the printing members off of the recording surface and polarizes them. The other is in series with a resistance and has its positive terminal connected to the receiver elements which are here also the printing members, while the negative terminal is connected to the slightly moistened tape. A ferrocyanide of potassium solution and iron tips to the receiver elements have been found to be cheap and satisfactory. The line circuits are connected to the receiving spools and temporarily change the magnetic flux as the signaling currents are received. It is found to be desirable to use various magnetic fluxes in the different circuits, but in every case the magnetic density is not large when the parts of the magnetic circuit are proportioned as in this receiver.

The five elements are mounted on a circular frame so that the printing faces nestle closely together and form the pattern already shown in Fig. 1. This pattern is only one of several which have been tested. The form of the alphabet produced by it seems to be entirely satisfactory. A sixth element could be added if greater perfection were desired, while an alphabet of four elements which was thoroughly tried out was found to be legible to most people, but vastly inferior in appearance and doubtful of acceptance by the public. A sample of the transmitting tape and of the message as received is shown in Fig. 7, although the dark blue record on a slightly tinted background is a difficult object to reproduce photographically, and it is impossible to do justice to the original. The reproduction serves, however, to show the forms of all the letters and figures as received over the whole of the artificial line, whose constants have been given, at a rate of 650 words per minute.

*The above equivalence is obtained by interpolation in the table on page 256 of "The Propagation of Electric Currents," J. A. Fleming.

The receiver is astonishingly consistent in its operation and it would probably be of interest to consider its functioning more in detail. The adjustment of the position of the core of a receiving magnet is accurately made by means of a reducing gear, all lost motion being avoided by the use of a stiff spring. After adjustment the receiver can be operated for a long time without any further attention. In one case, over four months elapsed without touching an adjustment screw, during which time it gave perfect service; then a break in the circuit made a repair and readjustment necessary. When a signaling current is received it will further magnetize the receiving magnet of one section of the receiver and reduce the magnetization of the one connected in series with it. The magnetization due to the local current lifts the receiver element from the paper and holds it against the core of the receiver magnet. When the signaling current slightly reduces the pull on the receiver element it is released and the spring causes it to strike the paper, leaving its record, and then to rebound, when it is again caught by the local magnetic circuit and held, ready for another release by the signaling current. The local current therefore does the work of distorting the spring and the signaling current merely supplies enough energy to release and to allow the stored up energy in the spring to become effective. The receiving

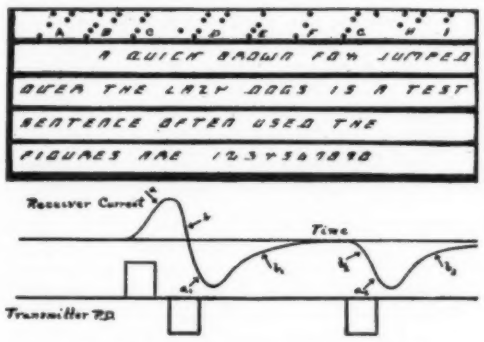
A QUICK BROWN FOX JUMPED
OVER THE LAZY DOGS IS A TEST
SENTENCE OFTEN USED THE
FIGURES ARE 1 2 3 4 5 6 7 8 9 0
Receiver Current
Time
Transmitter P.D.

Fig. 7.—Specimen of transmitting tape, and form of letters as received.

Fig. 8.—Current at end of a 375-mile artificial line, obtained by photographing osciliograph curves.

element has a flat spring rigidly attached to the core of the magnet which is energized by the local current. The natural period of the printing element can be made whatever is desired by varying the thickness or width of the spring and the size or location of the attached armature. The natural period of the receiving element should lie between rather sharply defined limits. Its period should be sufficiently long so that the signaling current has passed and the magnetizing current is again the controlling quality before it returns to its resting position; and the period should be short enough so that the receiving element is back at rest before another signaling current intended to operate it is received.

Let us assume that the transmitter connects batteries directly between a line and the ground either with or without the condensers, which are of service only when the source has large self-induction. Fig. 8 shows the current at the end of a 375-mile artificial line, due to the impressed constant electromotive force, as obtained by photographing oscillograph curves at both transmitter and receiver. The current is such as would be used in the vertical lines of a *G*. If we consider the negative current, which releases the element making the lower half of the vertical line for its two strokes, it can be seen that the natural period of the element should lie between definite limits. Since the element is more strongly held in place while the positive current impulse is on the line but is released when the negative current reaches a_1 and held again when the current is not more than b_1 then the period of the printing element should be longer than time between a_1 and b_1 but shorter than the time between a_1 and b_2. There is one exception that is of minor importance since it is desirable to avoid synchronism in general, that is, if the natural period is exactly as long as the interval from a_1 to a_2, then the second release will come at the proper time. If the natural period has a value such that the element returns to its initial position at any time between b_2 and b_3, except at a_2, then the resulting stroke will be given at the wrong time. This may not be so far wrong as to lead to illegibility, but will obviously give an imperfect result. The natural period used with this instrument as now adjusted lies half way between a_1 and a_2. This high natural period allowed the use of the "." marks, which are not considered a necessary part of the telegraph alphabet.

Hundreds of oscillograph records have been made, and it can be stated positively that with the present

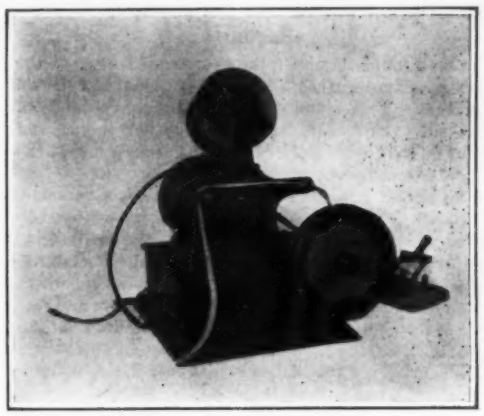

Fig. 6.—Receiver, with head lifted.

circuit and apparatus design no combination of currents can occur which will cause errors in the record. It is evident that a sufficient increase of speed or an increase in the length of the line without an appropriate reduction of speed will produce an inoperative condition, but as previously stated, the speed attainable is limited by the line and not by the terminal instruments.

The elements most frequently used are the two which combined make a straight upright line. This is produced, as already shown in Fig. 7, by connecting the battery to the line for 1/720 of a second and then reversing it for the same interval.

At the receiver, the current flow, so far as it materially affects the printing elements, is a sine wave of frequency 360 periods per second, as is apparent from an inspection of the oscillograph curves of Fig. 8.

The whole receiving and printing part of the mechanism can be easily held in the hand or carried in one's pocket. Aside from the paper drive and the power circuits there are only five moving parts and they consist of stiff flat springs rigidly attached to the frame. The movement of each is less than 1/25 of an inch (one millimeter) and there is no possibility of their getting out of order or needing adjustment. If the paper drive is started by a line impulse from the transmitter, a message could be received without the necessity of an attendant ever being present. The receiver, due to its extreme simplicity and entire absence of delicate parts, would have its first cost considerably less than that of a single sensitive relay. The cost of maintenance and operation will obviously be reduced to a minimum, since on account of its simplicity and speed the number of attendants and their individual skill will be far less than at present needed. Of the entire system, the most complex part as well as the most expensive is the commercial typewriter. It is not altered in any way, and if large users of the telegraph should themselves prepare the transmitting rolls the typewriters would be available at other times for general office purposes.

The widespread interest in and need for a cheaper telegraph service should undoubtedly lead to the adoption of some machine method of telegraphy which would make possible a large reduction in telegraph tolls.

Detecting Air Contamination from Gas Heating

A METHOD has recently been announced by which contamination of the air by products of combustion from gas heating apparatus that is quite simple of application. A piece of thick glass is chilled ice cold and held edge toward the fire and close to the cowl of the grate or stove. This test is made after the fire has been burning some time, and if there is any escape of the products of combustion into the room they will be condensed on the plate. Of course, this applies entirely to the better class of gas heaters which have a chimney connection. Of course, the cheap unconnected heaters so commonly used in cities discharge the entire products of combustion directly into the room and are most unhealthy.

Insulating Armature Coils

THE corona discharge from armature coils of generators that develop high voltage is very liable to injure the insulation and cause a breakdown, and various methods have been tried to improve the insulation. While mica answers fairly well it is not entirely satisfactory; but a new system in which a metal ribbon is used has been devised that is said to give excellent results. This method consists in covering the coils with layers of thin metal ribbon, each turn overlapping the preceding one, but insulated from it to prevent eddy currents. Experiments show that the insulation of an unprotected coil is gradually eaten away by corona, causing the formation of nitrous oxide and nitric acid fumes. This does not occur with a coil protected as described.

The Turbine, Diesel and Reciprocating Steam Engine

In reply to an inquiry from a correspondent as to the relative advantages of the steam turbine and Diesel engines over the reciprocating engine for ship propulsion, in regard to first cost, steam consumption, service and useful life, *International Marine Engineering* makes the following statement.

The question involves the consideration of so many factors as to make a comprehensive answer far too voluminous. Briefly, however, conservative engineering judgment, backed by experience in actual installations, seems to warrant the following generalizations. Direct connected turbines show excellent economy and are reliable for high-speed vessels and for these installations result in a saving of weight and space for propelling machinery. They are higher in first cost than a reciprocating steam engine installation.

For vessels of 15 knots or under, the principal turbine companies now recommend geared turbines, and even for high-speed vessels this is finding much favor. Confining attention to vessels of the cargo-carrying class at speeds below 15 knots, the margin between the several methods of propulsion is so small that local or economic conditions which may have no bearing upon engineering features often are the deciding factors.

A careful comparison of two vessels of identical external characteristics, but with a reciprocating steam engine and Diesel engines for the propelling machinery recently appeared and gives an excellent account of several items in coming to a reasonable decision..[1] A table is appended giving this comparison and the comparison is extended in the same manner to include approximate figures for geared turbines. Allowance has been made for the difference in tonnage measurement and dead-weight carrying capacity which the systems involve. The vessel chosen for the comparison is 400 feet length between perpendiculars, 52 feet beam, 29 feet 9 inches depth, 26 feet 1 inch draft. Total deadweight carrying capacity in tons, 8,640 (steam), 8,775 (Diesel), 8,805 (geared turbines). Speed, 10½ knots; radius of action, 3,500 miles; fuel consumption, 1.6 pounds per indicated horse-power per hour; 1.6 pounds per indicated horse-power per hour (reciprocating); 1.2 pounds per indicated horse-power per hour (turbine); .61 pound per indicated horse-power per hour (Diesel.)

In general, for moderate speed ships which would be driven by a single reciprocating engine, a Diesel engine ship is more costly, as the machinery is more expensive and the hull also, on account of the twin screws, oiltighwork, etc., but the space occupied by propelling machinery is less and the weight is less, so that there is a gain in cargo-carrying capacity and weight. At the present state of development Diesel engines are not suitable for high-powered vessel from engineering rather than economic reasons.

Geared turbines undoubtedly operate on increased economy, but there is little difference in the machinery weight and space and the first cost is higher than the standard machinery. A gain claimed for them is the absence of racing during heavy weather, which, however, is always less noticeable in any form of twin screw drive. The item of first cost is so important that it oftentimes settles the question out of hand, as it persists in the shape of increased insurance, etc., throughout the life of the vessel, and may transform receipts from profit to loss.

There is but little to choose as to reliability between the various systems, and figures are not available as to length of useful life. It is probably questionable, however, if either Diesel engines or geared turbines will have as long a period of usefulness as the present standard steam engine of the reciprocating type.

It is interesting to note that if the price of oil for the Diesel engine rises above that indicated in the table, or the price of coal falls below the given price, the margin quoted is seriously affected and may be reversed.

[1] "The Relative Possibilities of the Diesel Oil Engine, Geared Turbine and Suction Gas Engine." North East Coast Institution of Engineers and Shipbuilders, 1912.

Capital Invested.	Oil Engine $381,000		Steam Engine $308,000		Geared Turbine $351,000	
	Per Voyage	Per Month	Per Voyage	Per Month	Per Voyage	Per Month
Insurance	.....	$2,390	.....	$1,800	.....	$2,050
Fuel (oil at $9.77, coal at $3.66)	$1,756	.....	$2,170	.....	$1,738	.....
Wages and provisions	.....	1,700	.....	2,000	.....	1,950
Wear and Tear	.....	537	.....	488	.....	439
Deck and engine-room stores	.....	537	.....	488	.....	488
Port charges, at $1.22 per ton	3,680	.....	3,590	.....	3,590	.....
	$5,436	$5,164	$5,760	$4,776	$5,328	$4,927
16 voyages	87,000	.....	92,200	.....	85,300	.....
12 months	62,000	.....	57,300	.....	59,200	.....
	$149,000	.....	$149,500	.....	$144,500	.....
5% depreciation	19,000	.....	15,400	.....	17,550	.....
Management	2,440	.....	2,440	.....	2,440	.....
	$170,440	.....	$167,340	.....	$164,490	.....
Freight-earning cargo carried, tons	16 × 8,530	= 136,480	16 × 7,880	= 126,080	16 × 7,910	= 126,560
	170,440.00 / 136,480.00 = $1.25 per ton		167,340.00 / 126,080.00 = $1.33 per ton		164,490.00 / 126,560.00 = $1.30 per ton	

Forest Fires

THERE were four hundred fires last year on the national forests of Utah, southern Idaho, western Wyoming, and Nevada, or fifteen more than in the most disastrous season of 1910, yet the cost of extinguishing them was only one third and the damage only one thirtieth of that of the earlier year. The difference is due to better organization now by the Forest Service of the Department of Agriculture, and to more roads, trails, and telphones.

The principal causes of forest fires are lightning, campers, and railroads. The reports for one district in Utah show that lightning was responsible for 36 per cent of last year's fires and campers for 27 per cent. While campers are gradually learning the importance of care in regard to their fires, it is not likely that any amount of warning will entirely eliminate the carelessness and indifference that exists in many men. What part the railroads had in starting fires is not stated, but what a railroad can do was illustrated by an incident in California. A small railroad operating an oil-burning locomotive in the Tahoe national forest had a breakdown during the past summer and burned wood instead of oil for one day. On this day fifteen fires started along the right of way. During the preceding year only one fire occurred near the railroad and it was not thought that the engine was responsible for that one.

Present Production of Crude Tar Products

THE handling of coal tar and its further treatment are concentrated in a few hands, as is the case in Germany. This has given to the industry a pronounced unity and economy. Consumers of coal-tar crudes state that there has been a marked disposition to meet their needs, and to so adapt and modify manufacturing processes that domestic demands may be met as far as general market conditions permit.

In 1911 the amount of coal tar subjected to distillation amounted to 56,000,000 gallons. The remainder of the tar production was employed in the manufacture of roofing paper and for sprinkling streets. There is not much attempt to obtain separate products in a state of purity. The most important products are the light oil, creosote oil, and the residual pitch. These articles can compete successfully with European products. The light oil, containing benzol, etc., constitutes about 1 per cent of the tar. It is used largely for a solvent, for cleaning purposes, and as an illuminant. The creosote oil constitutes about 23 per cent of the tar and is used extensively for preserving timber. The domestic supply is far from covering the current demand.

In 1914 the United States imported 61,000,000 gallons of creosote oil, valued at $3,840,000, Great Britain supplied 41,000,000 gallons, Germany 10,000,000, and the remainder came largely from Belgium and the Netherlands. The home production of creosote oil in 1909 was 13,000,000 gallons. It has about doubled since then.

With regard to the production in the United States of the coal-tar crudes, necessary for dyestuff manufacture, the following is the situation:

Benzol, Toluol, Xylol.—Such limited amounts as have been called for to make intermediates in American works, about 500 tons annually, have been supplied the last few years. Provision can be quickly made for an ample supply on a much more extensive scale if a permanent demand is evident.

Phenol, or Carbolic Acid.—The method of treating American coals is such as to favor a relatively low production of phenol in coal tar. There has been little attempt to separate, regularly, technically pure phenol from the tar distillates.

The American demand is covered mostly by importations from abroad. In 1913 American imports were valued at $675,000. Of the import of 4,077 tons, Germany supplied 1,354 tons, Great Britain 2,422 tons, and the Netherlands 287 tons. The average price was $166 per short ton. In addition to furnishing material for a variety of important dyes, phenol has an extended use in medicine, in the manufacture of explosives, and in various industries. One important chemical made from phenol is salicylic acid, widely used in medicine as well as in the manufacture of artificial dyes. This is imported to the extent of 32,000 pounds. Another derivative is picric acid, used as an explosive and a dye. The import is 85,000 pounds, valued at $18,000.

The embargo on exports of phenol from Europe during the last few months, on account of its importance in connection with military supplies, has forced American chemists to fall back on its synthetic production from benzol. The operation is relatively easy. It is based upon the transformation of benzol into its sulphonic acid by the action of sulphuric acid, and the fusion of the product with caustic soda. With an ample supply of benzol the manufacture of synthetic phenol in the United States can be readily assured, at a cost not much in advance of that of the European product.

Naphthalene.—This is a leading constituent of coal tar and furnishes a variety of derivatives employed in dye manufacture. The bulk of the pure product is used as a moth preventive. The United States consumes annually about 5,000 short tons. Nearly 1,600 tons are supplied by American tar distillers. The remainder comes from Germany and Great Britain, in about equal amounts. Phthalic acid, one of the most important derivatives of naphthalene, is imported to the extent of 38 tons annually, with a value of $21,000. Naphthalene is a prominent constituent of the fraction of creosote oil obtained in the distillation of coal tar. It is a purely commercial question to the tar distiller, whether he can more profitably sell the crude creosote oil or separate out the naphthalene present therein.

Anthracene.—This hydrocarbon is also present in the creosote oil, and the same question arises as to the profits of its separation. No attempt is made in American tar works to isolate this valuable constituent, which serves as the basis of the manufacture of synthetic alizarin and all the alazarin dyestuffs.

The same method may be said of the relatively small but still important amounts of cresol, methylanthracene, phenanthrene, and carbazol, all of which occur in the creosote oil, and all of which are essential to an industry providing all current artificial dyestuffs. It should be mentioned here that the quantity of anthracene present in the coal tar now treated in American tar works is far in excess of that required to manufacture the alizarin dyes imported into the United States, while the naphthalene present could more than meet the demands of the world's entire dyestuff manufacture.

A competent authority gives the following estimate for products of the coal-tar industry in the United States for 1914: Total production of refined benzol in all forms, 2,550,000 gallons, or about 9,600 short tons (of this amount, 200,000 gallons, or 750 tons, was devoted to the manufacture of aniline compounds); total production of refined toluol, in all forms, 840,000 gallons, or about 3,200 tons (nearly all used for making explosives); production of refined phenol, 75 tons; production of refined naphthalene, 1,500 tons.—From the Report of Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.

The Electrolyte in pocket lamp batteries in Germany has been thickened with wheat or rye flour. To save this food material it is now recommended to use glass wool, kieselguhr or gelatine.

Searchlights and the Visibility of Distant Objects*

Conditions Involved in Their Use and Suggestions for Increasing Their Power

ALTHOUGH the main field for the employment of searchlights is in connection with naval and military operations, they have considerable application in other directions. They are used, for instance, in the navigation of canals and narrow channels, while it will be remembered that at the time of the loss of the "Titanic" much was made of the suggestion that they should be employed for look-out purposes in ocean navigation. The powerful locomotive head-lights used in the United States and elsewhere are also forms of searchlight, while our own motorcar lamps are in essence the same thing. We do not know that there is any official definition of a searchlight, but for the purposes of general discussion it may be looked upon as an appliance intended to illuminate objects at a distance, as distinct from a beacon or signal lamp, which is itself intended to be seen from a distance.

The design of a searchlight naturally depends on what it is to be used for. For military purposes, the greatest possible intensity of light in a particular direction is probably generally required, although even here too narrow a field of vision will not be desirable, and it is doubtful if it would be worth while to attempt to reduce the 2 degrees to 3 degrees of divergence from a parallel beam which necessarily follows from the optical imperfections of our sources of light. For ocean navigation, however, and iceberg detection, if such a use ever became common, it is quite likely that a comparatively large divergence would prove desirable. In motorcar lamps one gets still other conditions, in which it is desirable to illuminate the road without dazzling the passer-by. Somewhat the same requirements apply in the case of locomotive head-lights, and in America some trouble has been experienced owing to the dazzling effect of too powerful lamps. For a given source of light, the greatest range will be obtained with a parallel beam, so that, for what are ordinarily called searchlights, an approximation to such a beam is always used. The range of a searchlight is a somewhat indefinite quantity. Mr. J. S. Dow suggests that it may be as great as 10,000 yards, but the figure is dependent on the state of the atmosphere, and on the color and size of the object one is looking at. Clearly no searchlight can render visible an object that could not be seen under normal conditions. We believe it is not usual for makers to specify the range of their searchlights, but the matter is really merely one of definition. Mr. Dow states that in some parts of the country there is a police requirement to the effect that motorcar head-lights must have a beam 30 yards long, which, in the absence of any definition of a beam, is meaningless.

The two quotations from Mr. J. S. Dow which we have given above are taken from a lecture on this subject which this gentleman delivered before the Optical Society. Mr. Dow, in a brief way, reviewed the greater part of the field of searchlight construction and use, but it is not necessary that we should attempt to follow him in this task. A brief notice of some of the more interesting points he raised may, however, be made. We said above that it is not the practice of the makers of searchlights to specify their range. In the same way it is not their practice to specify the candle-power; they content themselves with the current consumption. It is usually held that the candle-power of a searchlight cannot be specified, since a parallel beam does not follow the inverse square law. Apart from atmospheric absorption, a truly parallel beam gives the same amount of light on a plane perpendicular to it no matter at what distance away from the lamp. Mr. Dow thinks, however, that the difficulty in stating the candle-power of a searchlight is largely a theoretical one. Owing to the fact that the sources of light available are not true points, a searchlight beam is really made up of a series of cones of light, each of which follows the law of inverse squares, and Mr. Dow is of opinion that no real difficulty lies in the way of specifying the candle-power in the same way as is done for any other source of light.

In the course of his lecture Mr. Dow described the Beck searchlight, which has given such remarkable results. It will be remembered that the essential point of the lamp is that the arc is maintained in an atmosphere of burning alcohol, and that three to four times the light is obtained from the same current consumption as compared with an ordinary arc. Some discussion arose after the lecture in connection with this point. One speaker wished to know if the improved efficiency of the new lamp must not depend on an arc of greater dimensions than in ordinary lamps, since all arcs had the brilliancy of incandescent carbon, so that it was difficult to see that any greater intrinsic brilliancy could be obtained in the Beck arc. We think the idea not correct. We believe we are right in saying that the maximum light in a searchlight beam depends only on the intensity of the source of light, so that the greater range of the Beck lamp necessarily involves greater intensity at the source. An ordinary arc appears to be dimmed to some extent by the cloud of carbon evaporated from the area surrounding the tip. This evaporation begins at 1,800 deg. Cent., although carbon does not boil until 4,000 deg. Cent. In the Beck arc the outer parts of the carbon tips are cooled by the atmosphere of burning alcohol, which has a temperature of about 1,000 deg. Cent., so that this evaporation does not take place. One seems to get the true arc quite unobscured. At the same time it must be remembered that the Beck positive carbon is cored, which may have some effect on the matter. There seems no doubt but that Beck gets greatly increased intrinsic brilliancy. An interesting matter mentioned by Mr. Dow was that Lummer, in Germany, has been able to obtain increased current density in arcs, and so increase the power of searchlights, by making the arcs under enormous air pressures. From the point of view of convenience and portability this method would, however, appear greatly inferior to that used by Beck.

In military operations it is frequently of great importance that a searchlight should not have to be extinguished for considerable periods, and this necessity has led to the construction of twin lanterns mounted side by side, so that when necessary one can be put out for the purpose of inserting new carbons while the beam is maintained by the others. If possible, searchlights should also be constructed so that they will not be put out by shock or vibration. Much difficulty is at times experienced in naval work owing to the searchlight arcs being extinguished by heavy firing. The Beck lamp is said by Mr. Dow to possess excellent characteristics in this respect. It is interesting in this connection to remember that searchlights may be employed to dazzle an enemy as well as to enable one to see. The landings at the Dardanelles are said to have been greatly assisted by the searchlights from the fleet playing on the Turkish entrenchments while the troops landed in the dark spaces between the groups of beams. It is, however, not only the enemy that may be dazzled by a searchlight, as the blue haze surrounding the beam may seriously interfere with the operator if he is standing close by. For this reason methods of controlling the movements of searchlights from a distance have been developed. These enable the observer who is operating the lamp to take his stand well away from it and free from any effect due to the blue haze. According to Mr. Dow, in some recent forms of control the searchlight automatically follows the movements of the observer's telescope.

In connection with the range of searchlights, Mr. Dow states that late work suggests that in ordinary clear weather the absorption of light is much less than has been generally supposed. The range, however, greatly depends on what one is looking at. In clear weather and with the naked eye it is said that while a white ship's light can be seen five miles away, the red and green can only be seen two miles away. Further, the center part of the retina is more sensitive to red than to green, so that if one looks at the light sideways he will see the green first, but if he looks straight he will see the red first. We do not know that this effect directly concerns the use of searchlights, but somewhat similar phenomena do. It is well known that at low intensities of illumination the maximum sensibility of the eye shifts toward the blue end of the spectrum. This effect is apparently of importance in connection with the Beck searchlight. The light given by this lamp is bluish-white, and the beam of an ordinary searchlight looks quite yellow alongside it. As is generally known, yellow and red rays have better penetrating power than blue ones, and the color of the light would therefore appear to be a weak point in the Beck apparatus.

Mr. Dow dealt with this point. Admitting the poorer penetrating power of the blue rays, he thought the proved superiority of the Beck lamp might be explained in the first instance by the fact that with it there was not nearly so great a nebulous haze surrounding the beam. This followed necessarily from the smaller light source. The effect would be that an observer using the lamp would see his objects through much less haze than was the case with an ordinary lamp. This would improve his vision, and would, in effect, improve the searchlight. A second explanation of the superiority of the Beck lamp, in spite of its color, lay in the Purkinjie effect, the shifting of the maximum sensitiveness of the eye at low intensities of illumination. At normal intensities the maximum sensitiveness of the eye lay in the yellow-green; at low intensities it shifted into the blue. The Beck beam had 30 to 40 per cent of blue light; but as at distances of two to five miles the intensities being dealt with were very low, one was employing the color to which, under the conditions, the eye was most sensitive. It is clear that, in addition to these effects, if the intrinsic brilliancy of the Beck arc is sufficiently high, it may outweigh any defects of penetrating power which the color may introduce.

The visibility of an object in a searchlight beam depends, of course, on the object as well as on the searchlight. One employs khaki or gray uniforms in order that they may approximate to the color of their surroundings and so be less easily visible, but the effect works both ways, and it is said that it has not always proved convenient for our men to be too difficult for our own gunners to see. A further point is that at night gray or khaki will be more easily seen than the French red. We believe this red in a Beck beam would appear quite black and be almost invisible. The visibility of troops by searchlight will depend greatly on the intensity of light available, and the Purkinjie effect will come in. The method of rendering an object difficult to see at a distance by spotting or checkering its surface is well known. The old Southsea forts form an example. The idea of the process is in effect to break a large object up into a number of small ones. Mr. Dow pointed out that the method is a very common one in Nature. In such cases, however, one usually has the initiative effect. A tiger moving among reeds and long grasses is striped vertically; while a panther moving among foliage is spotted. Mr. Dow says that if one has a donkey and a zebra in a field, and they both run away at the same speed, the zebra will disappear first. We have never tried the experiment, but we believe him.

* From *Engineering*.

Position of the American Tar Distiller

THE tar industry of the United States is on a different basis from that of Europe. In Europe its importance is confined almost entirely to the production of raw material for a highly organized chemical industry. Here the use of tar itself is widespread, while the utilization of its chief constituent, pitch, is confined to very narrow limits across the ocean. Pitch forms 70 per cent of coal tar. In Germany little use is made of it except as a fuel. Nine tenths of the pitch supplied by American tar works is employed in road making, in roofing, and in general waterproofing.

The very extended use of creosote oil in the United States makes it a purely commercial question as to whether the tar distiller should attempt a refining of its constituents. The current demand in America for benzol, toluol, and xylol is entirely met by the product from the benzol towers of coke plants.

To attempt any extended provision for supplying the entire range of coal-tar crudes, such as might be required in the United States for the manufacture of its own supply of artificial dyestuffs, would mean an assurance that the distiller could profitably dispose of nearly all of the products isolated in a more or less pure form during the various processes, and secured in far different proportions from those required in the general manufacture of coal-tar dyestuffs. At once he would face a very delicate and complicated problem, with many factors, technical, economic, financial. A dominant factor is an assured market, if he enlarges his plant on a scale comparable with foreign establishments.

Less than 10 per cent of tar consists of matters available for use in the dyestuff industry. If a distiller attempts to meet the needs of a growing or rapidly expanded domestic dyestuff industry, he must find channels for disposing of the remaining 90 per cent.

The tar distiller feels that he should not be expected to embark in the manufacture of intermediates, but that this branch should be undertaken preferably by the producer of heavy chemicals, as the production of intermediates means a heavy consumption of acids, alkalies, and a variety of other chemicals.

There seems to be no lack of enterprise in the tar-distilling branch; but there does seem to be a deep-seated conviction that fundamental changes in legislation are absolutely essential before any far-reaching effort can be organized, to assure the preparation from American coal tar of an adequate supply of "crudes" for the needs of a self-contained American coal-tar dyestuff industry.—From the Report of Bureau of Foreign and Domestic Commerce, U. S. Department.

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An Austrian searchlight station in the Carpathians.

Fig. 2.—An automobile transport for carrying large searchlight apparatus.

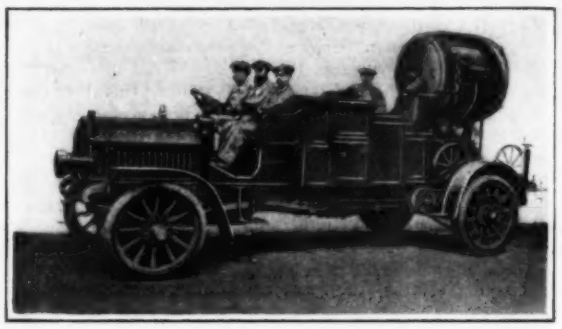
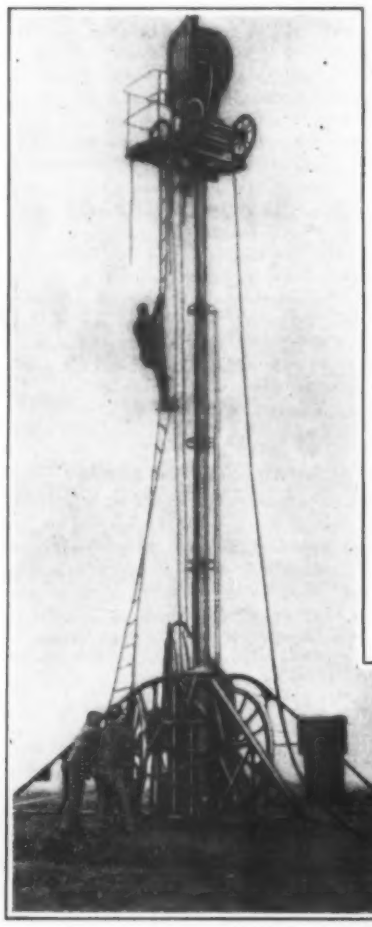


Fig. 3.—Another type of automobile for carrying a portable light.



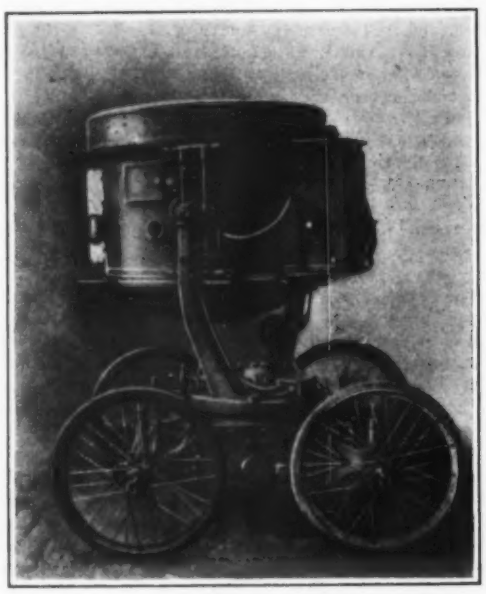


Fig. 4.—Projector for observing aircraft.

Fig. 1.—Searchlight mounted on telescopic mast.

Russians operating a powerful light in the field.

Watching the Enemy from the Fighting Line

New Devices Made Necessary by Modern Methods of War

THE war by stratagems, surprises, and ambush in which we have been engaged for nine months, says a writer in *La Nature*, has necessitated a complete change not only in fighting methods, but also in military equipment.

It was foreseen that fighting would not stop with daylight, but it certainly was not thought that night attacks would be so numerous and often repeated, and that, as a consequence of trench warfare, during night only could soldiers be shifted from positions, lines be reinforced, new earthworks prepared or fighting resumed. Thus, the ordinary kind of lights and illuminating skyrockets was soon found to be insufficient, and it became necessary to create a new equipment that would meet the war requirements.

What are these requirements? For field-troops, it is necessary to produce a very strong light. Movable lights have therefore been decided on and these are auto-searchlights. These appliances may be rapidly transported from one point to another, fulfill their mission and be withdrawn before having attracted the enemy's artillery fire.

For a less *mobile* service, use is made of transportable searchlights of higher power. The following is a description of the newly designed types put into service:

The apparatus consists of an automobile truck with a platform for carrying the searchlight, which is mounted upon four wheels and which may be readily loaded or unloaded by means of an inclined plane, with the help of a windlass. A crude-oil engine on the truck drives a dynamo, the current of which feeds the arc of the searchlight by means of a cable 250 meters long that is carried upon a reel. The searchlight can be stationed this distance away from the truck, if necessary. The outfit may thus be put to work either on the spot or from a distance. A portable controlling station weighing not more than 4,000 pounds includes the necessary switches and may be taken to any point desired.

A cylinder of sheet metal of new design contains a powerful arc lamp, the carbons of which are arranged horizontally, the luminous point being constantly adjusted to the focus of the parabolic reflector by means of an electromagnetic movement. The regulation of the distance between the carbons and their centering may be effected either by hand or by means of a small wheel located at the rear of the drum. The diameter of the reflector-mirror is 90 centimeters. The segmented mirror used has a number of advantages for military use where apparatus is subject to damage.

The orientation of the searchlight is effected by the rotation of the lamp upon a vertical axis secured in the pedestal; the movement of inclination is obtained by rotating the lamp upon its trunnions, which are supported in stationary bearings.

In order to enable an observer to distinguish clearly the objects upon which the luminous beams are thrown, he must stand at one side of the searchlight, at a distance of 200 yards away from the latter. When it is necessary to change the direction of the luminous beam, the observer, by means of the switches of the control-

ling station which he has carried along with him, sends a current into the two small motors located in the pedestal of the apparatus, the rotation of which brings about the desired vertical and lateral movements. The engine of the truck is a four-cylinder, 30 horse-power engine, placed in the usual manner under a hood in the front part of the vehicle.

Adjoining the hood is the main seat, against which are placed the lockers and reels, and in the rear is the platform which supports the searchlight wagon. The normal operation of the motor corresponding to that of the dynamo is 1,100 revolutions per minute.

In another device the searchlight, mounted upon a carriage, is hooked to the rear of an automobile which, when separated from this carriage, may be utilized for staff services. This searchlight may also be attached to the rear part of a carriage drawn by horses. A second cart, also drawn by horses, carries the electrical plant, the motor and dynamo, and the reel for winding up the cable which transmits the current to the lamp.

In stationary outfits, in the vicinity of fortified places or in hilly country, the searchlight must be mounted upon rising ground, so that it may cover a wide area. A remarkable apparatus, unique in its kind, is shown in Figs. 1 and 4. The searchlight is separate; 100 yards away is the generator of electricity, and the same distance away stands the observer. The whole is illustrated in Fig. 1. It is composed of an electro-pneumatic elevator mounted on wheels and attached to the rear of the automobile which carries the electric generator and the searchlight of 23 inches diameter.

The elevator consists of a telescoping tube, the extension of which is effected by means of compressed air. The compressed air is produced by an electrically-operated compressor at the lower part of the tube.

The luminous focus of the searchlight is thus lifted to a point about 45 feet above the ground, and the searchlight is carried on a platform to which the operator, if necessary, has access by means of a rope ladder.

The lamp is automatic in its operation. All lateral, horizontal and vertical movements are controlled from below by means of a portable starting station connected with the apparatus by means of a cable of 100 yards length, so as to allow the observer to stand a distance away from the searchlight.

At the observation station the aim upon the point to be observed is effected by means of a prismatic binocular, the optical axis of which is parallel to the optical axis of the searchlight. This parallelism is maintained during the operation by means of an electric adjuster so that the beam of the searchlight is always in the optical field of the prismatic binocular, lighting the object under observation.

Until recently searchlights have been used only horizontally, or with slight inclination, but the presence of airships has made it necessary for searchlights to operate vertically in upward or downward directions.

A searchlight is substantially composed of a source of high luminosity and of small dimensions. A source reduced in size down to a point would be theoretically ideal, but, from the practical point of view, the exploration of a given area by means of a very thin beam would be impracticable. The luminous source is formed by an electric arc placed at the focus of a mirror. The positive crater gives off the most light and this crater is held in the focus by means of very ingenious adjusting devices. In order to obtain a parallel luminous beam, use is made of a parabolic mirror.

Concerning the length of the beam of a searchlight, it is conditioned upon a considerable number of factors. First, the state of the atmosphere. In normal weather a searchlight using a current of 150 amperes may throw a beam of 10,000 yards. But it is not only necessary to have at one's disposal a searchlight sending out luminous rays, it is still further necessary to render visible the objects illuminated. The visibility depends to a large extent upon contrasts. Thus a person dressed in light gray or even in blue is visible at a greater distance than a person dressed in black. With a luminous power of 8,000 candles the distances found were about 350, 180 and 125 yards. Whereas, during night, the background is dark and the illuminated object is sharply outlined against the black background (except if it is very near to a wall); during daytime, all the background of the landscape is more or less strongly illuminated.

Considering the uniforms of infantry, it will be seen that grayish blue clothes which, displaying a minimum of visibility during daytime, are much more visible during night than brown or dark-blue clothes, particularly if the projections are made by electric light richer in blue and violet rays than other artificial lights.

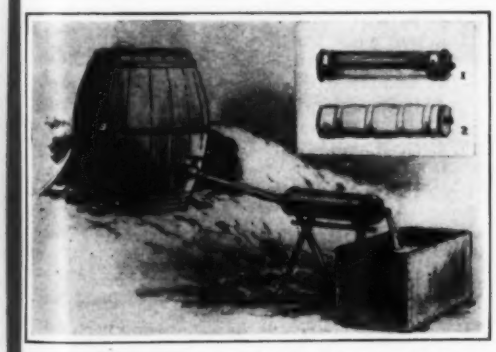
Owing to the defects in the correction of the eye, monochromatic light gives visual acuteness superior to polychromatic light. Projectors with gilded mirrors, preserving the most useful portion of luminous rays and considerably decreasing the number of very refractive rays, favor visibility. In order to increase the contrasts of shades of illuminated objects, the direction of aim of the observers should make an angle as wide as possible with the direction of the luminous beam.

It will thus be seen how large is the number of factors that intervene in the establishment of the useful length of beam of a searchlight.

Pure Water for the Army*

Various Forms of Field-Service Filters

THE use of impure water is a fertile source of epidemics, and must be avoided at all cost. Various devices are therefore employed by troops in the field to purify, and so render useful, whatever water may be available. Impurities are held in water either in suspension or solution. The first of these may generally



For providing an ever-ready supply of purified water in camp. Barrel reservoir with pipe-syphon led from the source and flannelette strainer.

(1) Strong wire cage with perforated central tube. (2) The wire cage with flannelette of good quality fastened around it. (3) Metal container within which the covered wire cage is placed.

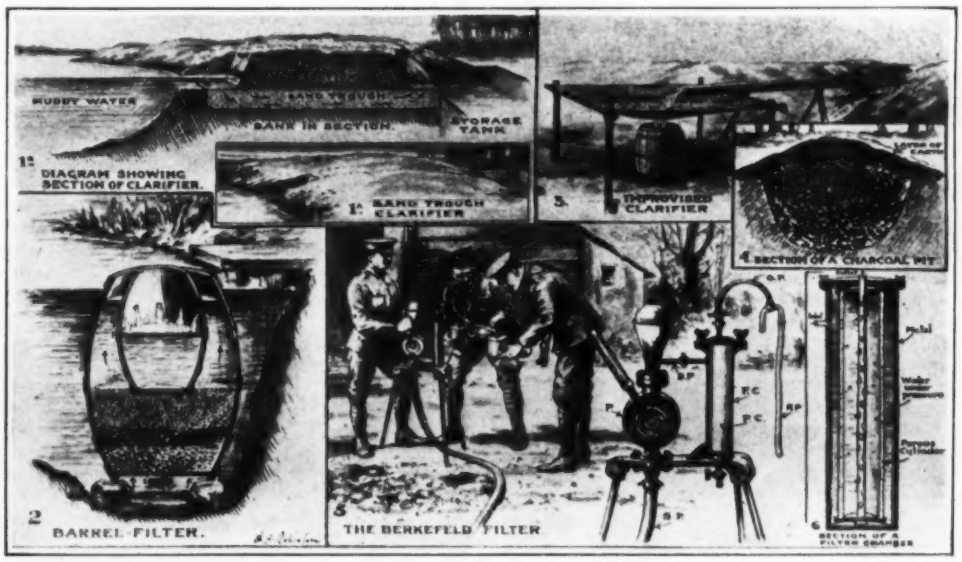
be removed by filtration. The second have to be dealt with by the addition of substances which combine chemically with the dangerous matter, the combination forming other substances not dangerous. Clear water may be obtained from a muddy river by digging a storage-tank at a distance from the river, with which the tank is connected by means of a trough filled with fine sand. The water as it percolates through into the tank leaves its deposit in the sand.

A similar type of filter, more effective in action, but of a smaller capacity, may be constructed from two barrels or casks, the larger cask having a perforated bottom. Having been placed in the stream so that its upper edge is above the surface of the water, the bottom of the cask is covered with a layer of coarse gravel. Upon this a layer of charcoal is deposited, and upon that again a layer of fine sand or gravel. The smaller barrel is now placed inside the larger one with its bottom resting on the fine sand. Lastly, a number of holes are bored in the upper part of the sides of the smaller barrel. The water enters the large barrel through the holes in its bottom and, passing upward through the gravel, charcoal and fine sand, finds its way into the small barrel, where it will be found to be in a comparatively pure state.

A large quantity of water may be clarified in a short time by means of an improvised filter consisting of a blanket or cloth stretched over a rough framework of poles. In emergency, lances, or even rifles, may be utilized, being covered with a layer of wood ashes from a camp-fire, or, indeed, with fine sand only. When sand, however, is used as a filtering medium, special care must be taken to insure that it contains no injurious germs. To make certain on this point, the sand should be heated to a high temperature before being used. Charcoal, when obtainable, is better than sand, as it is of itself a purifying agent.

To convert wood or peat into charcoal a pit is dug in the ground and a fire is made in it, wood or peat being added until the pit is almost full. As the fuel burns and the embers sink down, additional fuel is piled on, finally raising the heap of ashes above the ground level. A thick layer of earth is then spread over the top, so as to exclude all air and cause the fire inside to die out before complete combustion is effected.

The Berkefeld Filter is a convenient form of portable filter combined with a lift-pump. Its action is as follows: A semi-rotary pump *P* draws water from the more or less contaminated supply by way of its suction-pipe *S P* and delivers it to a filter-chamber *F C* by the delivery-pipe *D P*. The filter-chamber is provided with a porcelain cylinder *P C*, the bottom of which (in the diagram the outer case is broken away to show *P C*) is closed, while the interior is in communication at the top end with the outlet-pipe *O P*. The water is forced into the filter-chamber (see additional Fig. 6) by the action of the pump, and finding no other outlet, passes through the pores of the porcelain cylinder, and thence in a purified state through the outlet-pipe *O P*, the impurities having been arrested in the pores of the porcelain cylinder. A tap is provided at the bottom of the filter-chamber in order that a stream of water may be pumped through the filter-chamber to wash the exterior of the porcelain cylinder without passing through it. The cylinder, further, may be entirely removed by way of the lid at the top of the filter-chamber. The outlet-pipe is usually provided with a Y piece fitted with two nozzles to which rubber pipes *R P* may be attached for the filling of water-bottles.



A variety of easily constructed filters.

An Application of Arc or Acetylene Welding that promises to be very valuable is in the mending of worn flanges on the wheels of railway cars. The expense is small and it saves a very considerable shortening of the life of the wheel that would result from a repair by turning down the tread. The process can also be employed to restore flat spots on the tread of the wheel.

* From *The Illustrated War News.*

The Medicine of the Old Testament—II*

Primitive Remedies, Practice and Superstitions of Ancient Palestine

By Stuart B. Blakely, M.D.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2065, Page 71, July 31, 1915

EYE diseases and blindness were, and still are, common in the Orient, due to neglect and to the blinding glare of sun and sand. Leah was "tender-eyed" because she had ophthalmia (Gn. 29, 17). Sudden blindness—transient or permanent—was not uncommon. The loss of sight due to advancing years was well known. Isaac (Gn. 27, 1); Jacob (Gn. 48, 10); Eli (I Sa. 3, 2; 4, 15). Moses had probably the farsightedness of old age (Dt. 34, 7).

The venereal diseases, gonorrhea and syphilis, were prevalent among the ancient Hebrews. Irregular sexual relations were widespread. There are many references to prostitutes and brothels. Possibly the best known are Rahab of Jericho, Delilah the Philistine, and the two harlots—probably Greek—who came before King Solomon (Jos. 2, 1; Jdg. 16, 4–18; I K. 3, 16). Read Gn. 38; Ezk. 16 and 23; Proverbs 7 is a classic. Sexual perversions were very common (Gn. 19; Lv. 18, 21). The cities of Sodom, Gomorrah, and Gibeah were notorious for the number of sexual perverts among their inhabitants (Gn. 19, 5; Jdg. 19, 22). Much of the "uncleanness by issues" of Lv. 15 undoubtedly refers to gonorrhea. Syphilis is the only disease known that visits the sins of the father upon the children to the third and fourth generation. The word "emerods," also translated "tumors," which occurs in I Sa. 5, 6–9, and Dt. 28, 27, meant the sexual organs, and was used to specify disease of those organs. By making "golden emerods" and worshiping copies of the diseased parts (I Sa. 6) the people hoped that the disease itself would disappear, the idea that like cures like being a very old superstition. This was the plague of the Philistines and was undoubtedly a venereal disease, probably syphilis. The plague of Baal-Peor, previously mentioned, was almost surely syphilis. Nu. 5, 22–27; II Ch. 21, 13–15, may refer to syphilis. It has been claimed that Sarah, Abraham's wife, and David both had venereal disease. The passages quoted in support of this contention are not conclusive. Certain verses of Psalms have been said to refer to gummata of the bones, the subcutaneous tissues, and even the liver. It is fairly certain that the Hebrews recognized the relationship of sexual intercourse and certain diseases, as attested by several passages, especially in Proverbs (Pr. 2, 18; 5, 11–22; 7, 23).

There are a few special individual cases that are of interest. Asa died of a disease of his feet (I K. 15, 23; II Ch. 16, 22). It was probably not gout, but either senile gangrene or dropsy, because it "moved upward in his body." King Jehoram died of a cancer of the lower bowel, or of a severe dysentery at the comparatively young age of forty years (II Ch. 21, 18–19). King Hezekiah's disease is mentioned in three different places (II K. 20; II Ch. 32; Is. 38). It is described as an inflammation, or boil, and was cured by a fig plaster, or, literally, "by rubbing a cake of figs upon the boil." A very ingenious and not at all improbable theory is that this so-called boil was a neck abscess that later ruptured; for Is. 38, 14, reads "like a crane or a swallow so did I chatter"—the idea being that the abscess interfered with the action of the larynx and so with speech. We do not know what were the diseases of Abijah, Banhadad, Elisha and Joash (I K. 14; II K. 8, 7–15; 13, 14; 2 Ch. 24, 25).

There has been a great deal of discussion about Job's disease or diseases. The ancients believed that he had "black leprosy." The usual guesses—for that is all that they can be—are leprosy, syphilis, and Aleppom boil. It has been said that to fulfil all the symptoms presented, Job must have suffered from leprosy, elephantiasis, nightmare, gout, dysentery, ulcerated mouth, marasmus and lice! (Job 2, 7–8; 4, 13–15; 7, 3–5 and 13–14; 16, 8; 19, 17 and 20; 30, 17–18 and 27 and 30). It is probably better, at least for our purposes, to regard Job as an allegorical, rather than as an historical character.

Diseases and abnormal conditions of the nervous system were present among the Hebrews. The state of trance was recognized (Gn. 2, 21; 15, 12). Fainting attacks are told as occurring to Eli, Daniel, and Saul. Epilepsy was observed (Nu. 24, 4). Sun or heat stroke was not infrequent (Is. 49, 10). We read that "the sun shall not smite thee by day, nor the moon by night" (Ps. 121, 6). To be moonstruck meant either epilepsy or lunacy. Jonah was stricken by the sun and heat (Jon. 4, 8). The incident told of the widow's three-year old son in II K. 4, 18 refers in all probability to such a sun or heat stroke. The boy went into the harvest field to his father, he suddenly cried out, "My head, my head," and was taken home unconscious. Elisha was summoned and revived him. Another widow's son was revived by Elijah (I K. 17). This child's unconsciousness was probably due to infantile convulsions. Apoplexy and its results were recognized. Uzzah's death by the ark was probably caused by a stroke, possibly by an electric shock (II Sa. 6, 6–7). Nabal died of a stroke of apoplexy due to arteriosclerosis, following a drunken feast, a common occurrence as all physicians know (I Sa. 25, 36–38). The palsy of King Jeroboam was caused, probably, by the temporary arrest of an embolus or blood-clot, in a vessel of the brain, or of the arm itself (I K. 13, 4–6).

Of course, the ancient Hebrews had no classification of mental diseases. The belief in demons was widespread. Normal reason, normal mentality, and normal mental processes were to their minds, literally, the indwelling of the spirit of God. When a person's reason weakened or was lost, an evil spirit had entered into the individual. The person thus became insane. Insanity was not infrequent. David feigned madness, crudely but successfully, and so escaped from Achish, King of Gath (I Sa. 21, 13–15). Lunatics are carefully respected in the Orient. The two most noteworthy cases of mental disease recorded in the Old Testament are those of King Saul and King Nebuchadnezzar.

The case of King Saul is very interesting. The King of Israel was handsome, shy, self-conscious, of weak judgment and violent passions, easily exalted or depressed. He had troubles at home and abroad. His enemies pressed him hard. He was threatened with loss of his kingdom. He became a prey of fears, had premonitions of his own death and showed homicidal tendencies. Samuel was dead and the priests had been driven away. He had no one to advise or counsel. In disguise and at night, harrassed by haunting fears and loneliness, he consulted the witch of Endor. Little wonder that she could conjure up for his distorted mind, Samuel's spirit. Weak from lack of food and weak with fear he fainted. He had hallucinations of sight and hearing. Some time later, sorely wounded, his sons slain, his kingdom lost to the Philistines in battle at Armageddon, King Saul fell upon his sword and committed suicide. The development and course of King Saul's mental malady may be traced in I Sa. 16; 19; 22; 28; 31. It was either melancholia, or, more likely, manic-depressive insanity.

The other interesting mental case is that of King Nebuchadnezzar as related in the book of Daniel. This king of Babylon had visions of grandeur. A dream and its interpretation preyed upon his mind. He had hallucinations, ideas of persecution, and periods of exaltation followed by depression. At the end of a year he was driven away from men. He believed himself an ox, and for seven years lived as a beast, neglecting all care of his body, and eating grass. His was probably the mental disease called paranoia, though at the end of seven years he is said to have recovered his reason. The whole story has a legendary sound. Compare the story of the companions of Ulysses becoming swine, and other old Greek tales of lycantropy.

The mysteries of sex, pregnancy, and birth have always attracted and held the interest of all peoples of all times. The ancient Hebrews were no exception. No other medical subjects are so thoroughly covered in the Old Testament. The Hebrews discussed the primitive facts of life brutally, openly and unashamed. Without question, much that is really valuable has been lost to the most of us by the translators toning down or eliminating passages that might shock our sensitive modern ear.

We cannot enter into any of the interesting detail of the obstetrics and gynecology of the Old Testament. We can glance at but a few passages.

A very old belief of ancient cattle breeders in the influence of prenatal or maternal impressions on the offspring is recorded in the last part of Gn. 30. The close relationship of menstruation, nursing, and the menopause to childbearing was well known (Gn. 18; Hos. 1, 8). It was observed that miscarriage might follow bodily injury or mental shock (Ex. 21, 22; I Sa. 4, 19). Miscarriage is invoked in Hos. 9, 14. Barrenness was looked upon as an affliction, as a calamity, often as a punishment (Gn. 18, 9–15; 30, 2). Pregnancy and children, especially after years of sterility, were regarded as a blessing, as a gift from God (I Sa. 2, 5; Ps. 113, 9). Sarah is said to have given birth to Isaac at the age of over ninety years. Rebecca was barren for nineteen years. Manoah, Samson's mother, and Hannah were also elderly primaparæ (Gn. 18; 20; 21; 29; 30; I Sa. 1, 20; Judg. 13, 24). The nursing period often lasted two or three years. There are references to nurses and sick children.

Of the many births recorded in the Old Testament four are of special interest: (1) The death of Rachel in childbirth due to, or at least contributed to, by her age and the journey (Gn. 35); (2) the premature labor of the wife of Phineas, induced by the shock of distressing news, and her speedy death, probably from hemorrhage (I Sa. 4, 19); (3) the twins of Tamar, and the lacerated perineum (Gn. 38); (4) the twins of Rebecca (Gn. 25).

The two pairs of twins are interesting because the diagnosis of twins seems to have been made before birth, and also because both were hand presentations. One of twins is commonly larger and stronger than the other. This seems to have been the case with Esau and Jacob; besides, the former had an overgrowth of hair—hypertrichosis. The rules for the lying-in period are given in Lv. 12. The days for the "purifying" for a female child were longer than for a male child. This is traced to a very old superstition that it is more dangerous for a mother to give birth to a female child.

The Hebrews regarded old age as a reward for piety, as a token of God's favor. A hoary head was a crown of glory (Pr. 16, 31). David is pictured as old and stricken in years in I K. 1. One of the best descriptions of old age and death that has ever been written is found in Eccl. 12. The Preacher speaks in highly symbolic terms. It is the picture of an old man. The following seems to be the most reasonable explanation of the passage:

Verse 2. His mind, his physical well-being, often his prosperity fails. He is fretful and peevish, his pains recur, he often weeps and is depressed.

Verse 3. His arms and hands become weak; they shake and tremble. His legs are bent beneath their load. His teeth are few or gone; chewing is difficult. His sight fails, often from cataract.

Verse 4. His lips and cheeks are sunken, referring to the peculiar appearance of a toothless, aged person's face, especially when chewing, the doors being the lips, and the street the mouth. The sound of the grinding is low, because the mouth is shut and the teeth are few or gone. His early morning insomnia—very characteristic. The bird, or cock, is easily aroused and is early astir. He becomes deaf and his voice is cracked and quavering, the daughters of music being voice and hearing.

Verse 5. He is feeble; he fears new undertakings. His hair is white, the blossoms of the almond tree being of that color. There have been other interpretations of this passage. He has an annoying rupture, the belly of a grasshopper resembling the sac of a large inguinal hernia. A dried and shriveled up old man is often a burden to his friends. His sexual desire fails; or the caper berry—used as an aphrodisiac—shall fail to act.

Verse 6. His back is bent, his shoulders stooped, the silver cord being the white glistening ligaments that support the spinal column. The "golden bowl" is obscure. It may mean the watery eyes, or the chronic nasal discharge, so common in the old. It has been suggested that the loosing of the silver cord and the breaking of the golden bowl refer to the breakdown of his central nervous system, his spinal cord and his brain respectively. His bladder is weak, he dribbles urine. The circulation at his heart fails. It has been here suggested that the breaking of the pitcher at the fountain and the breaking of the wheel at the cistern refer to the breakdown of his circulation, venous and arterial.

Then shall the dust return to the earth as it was; and the spirit shall return unto God who gave it.

With a View to Promoting British commercial interests arrangements are being made to hold an exhibition in London next year that shall illustrate the natural resources of the Empire. This movement is in the hands of the Institute of Industry and Science of Great Britain and Ireland, and will be held under the auspices of the various dominions and colonies.

* Read before the Men's Forum of the First Congregational Church, at Binghamton, N. Y.

Hydrated Lime

Processes of Manufacture and Some of the Advantages for the Consumer

HYDRATED lime is a product recently put on the market to take the place of lump lime. As its name indicates, it is lime which has already been hydrated—that is, the chemical combination with the water has already taken place. It is a fine, dry white powder which is shipped in paper or burlap bags, and which may be used for any purpose instead of lump lime.

The keeping qualities of hydrated lime have been the subject of a great deal of discussion. The original statement which was generally accepted was that hydrated lime would keep indefinitely. On this assumption, samples were tested in their ordinary commercial packages. The average of eleven samples so received showed a content of 3.77 per cent carbon dioxide, and one of them contained 10.09 per cent. These figures correspond, respectively, to 8.57 per cent and 22.93 per cent of calcium carbonate or inert material which had presumably been introduced by air slaking in transit. In order to investigate this matter a sample of lime was ground and screened through a 60-mesh sieve, and part of this was hydrated. A sample of the quicklime and one of the hydrated lime prepared from the quicklime and having the same fineness were exposed to the action of the air under the same conditions and were analyzed for carbon dioxide at frequent intervals. The results are as follows:

ANALYSES OF QUICKLIME AND HYDRATED LIME

Age of sample (days).	Percentage of carbon dioxide.	
	Quicklime	Hydrated lime.
1	0.93	3.14
4	1.68	6.38
6	3.23	7.45
7	3.87	10.34
8	4.02	10.73
10	8.73	11.25

These figures seem to prove that hydrated lime will not keep any better than quicklime of the same fineness. The fineness is important, however, for an impervious coating of air-slaked lime will form on the top of a pile of hydrated lime and prevent access of the air to the interior of the pile.

The chief advantages to the consumer of hydrated lime are as follows: It can be handled more easily on account of its being in powder form. It will keep better than lump lime on account of its fineness. It does not require slaking, but must merely be soaked in water to prepare it for use. This saves time and labor and eliminates any danger of loss of lime due to unskilled slaking. Any unburned or overburned lime which has passed the sorter will not hydrate, and can be screened out of the finished product. Hence, hydrated lime should contain less refuse than lump lime. On the other hand, hydrated lime contains 15 to 25 per cent of water, on which the consumer must pay the freight.

Manufacturers reap several advantages from the operation of a hydrate mill. It gives them a product which can be stored, so that in case the orders for lump lime decrease unexpectedly the lime can be hydrated and stored and the kilns need not be shut down. There are several grades of stone in use which burn either to a dark-colored lime or one which falls to pieces in the kiln. Such lime can not be marketed in the lump, but will give a good quality of hydrate.

A very convenient method for testing hydrated lime is to determine its content of carbon dioxide. If properly made and stored, the proportion of carbon dioxide should be less than 1 per cent. Another method which might prove of value as a practical comparative test depends on the density of the material. Pure calcium hydroxide has a lower specific gravity than any other material which may be present in hydrated lime except water. Of nineteen samples of commercial hydrated lime tested by the Bureau of Standards, eight samples of good high-calcium hydrate showed densities between 2.15 and 2.24; seven samples of magnesian hydrates showed densities greater than 2.38; the other four samples showed densities between 2.34 and 2.38. Two of these four were high-calcium hydrates containing unusually large proportions of silica; one was a high-calcium hydrate with a large proportion of unhydrated (quick) lime; and the fourth was a magnesian hydrate in which the magnesia was hydrated (because of an unusually low temperature used in burning the lime.)

MANUFACTURE OF HYDRATED LIME.

Hydrated lime is manufactured on a commercial scale by a process essentially as follows:

Lump lime, as it comes from the kiln, is crushed to pieces one inch and smaller in diameter. This is done so that the lime can be handled mechanically, and it also serves to hasten the reaction between the lime and the water.

The lime is then fed into the hydrator. Theoretically, the only function which this machine has to perform is to mix the lime and the water quickly and thoroughly, in order to prevent the production of a burned hydrate. If there is not enough water present or if the lime and water are not mixed thoroughly, the heat generated by the slaking may be localized and may become so intense that it will change the physical qualities of the hydrate—notably, the plasticity will be diminished.

The hydrators commonly used are of two different types, intermittent or continuous.

The intermittent hydrator consists of a circular iron pan large enough to hold about 1½ tons of hydrated lime and capable of revolving horizontally. Suspended in the center of this pan is a fixed shaft with arms radiating from its lower end. These arms carry plows, which scrape the bottom of the pan, and are arranged in a horizontal spiral, so that every part of the pan is touched at least once each revolution. The whole machine is surmounted by a hood and stack to carry the dust out of the building.

In operating the pan it is first started revolving. A definite quantity of crushed lime is then fed in, generally from an automatic weighing bin. Then the water is turned on. The quantity of water used is sometimes regulated automatically by an overflow tank or some such arrangement, but more often it is left to the discretion of the man in charge. If the man is a good operator the latter method is probably to be preferred. A large proportion of the water added is given off as steam, and the steam generated depends on whether the room is warm or cool, and to what extent the machine has been heated by previous charges. Therefore, the quantity of water necessary is not constant and requires supervision. After the water has been added the pan is kept rotating until hydration is complete. This requires from 6 to 20 minutes, according to the quality of lime used. The end of the reaction can be readily discerned with practice. The powder becomes very light and appears dry, and the evolution of steam ceases. A central section of the bottom of the pan is then raised and the plows force the product through this opening into the bin below.

The continuous hydrator consists of a series of long iron tubes, one above the other, to save space. Within the pipes a screw conveyor is arranged which carries the lime through them. The lime is admitted at one end of the top section of the pipe. As close as possible to the end through which the lime enters a large vertical stack is erected. The water is admitted about two thirds of the way up this stack, and falls down it, over a series of baffle plates, into the pipe. Here it meets the lime. The two substances are mixed very thoroughly by the screw conveyor, and at the same time are carried by it through the tube. The conveyor is run at such speed that when the mixture has reached the end of the pipe, hydration is complete. In this machine it is impossible to regulate the quantity of water automatically, on account of the constantly increasing temperature (and consequent evaporation).

A comparison of the two hydrators seems to result in favor of the continuous. First, since the lime and water are admitted in small constantly flowing streams, a quicker and more thorough mixture is obtained. It is much easier to insure the presence of sufficient water for complete hydration; hence the danger of burning is diminished. The stream of water flowing down the stack absorbs the dust. This dust is a serious nuisance around a hydrating plant and makes the labor problem a difficult one. Besides absorbing the dust, the water also condenses the steam generated, and therefore enters the hydrator hot. It is a matter of common experience that a better quality of slaked lime can be obtained with hot water than with cold.

The quantity of water to be used in making hydrated lime is a very important factor. As already indicated, it must be varied to suit constantly changing conditions, and considerable experience is required to be able to tell by the appearance of the finished product just when the correct quantity has been added. Too much water will cause the product to become pasty and clog the screens. If too little is used more will be later absorbed from the air, with the consequent bursting of the bags in which it is stored. No practical means has yet been devised for determining the quantity of water present in the finished product, so that it must be judged merely by its appearance.

The hydration of lime is accompanied by an increase in volume which causes the lumps to disintegrate. Evidently, anything which does not hydrate will retain its original lump form and can be separated from hydrated lime by screening.

The next step, therefore, is to screen the material which comes from the hydrator. This may be done either by means of a screen or of an air separator. The screen ordinarily used consists of a wooden or metal frame covered with wire gauze of 36 diagonal mesh (36 wires per linear inch, with the diagonals of the square holes running lengthwise of the screen). An air separator is essentially a fan into which the hydrate is fed. The hydrate is picked up by the current of air and carried away, while any impurities settle to the bottom of the fan casing and may be drawn off. The air current passes into a large chamber, which so reduces its velocity that the hydrate settles and the air is taken back and used over again. The air separator has two great advantages over the screen: First, it can be built more nearly dust proof; and, second, it will distribute a hydrate so wet that a screen would be clogged. This permits the use of a little more water in the hydrator, with consequently less danger of burning.

The hydrate is now taken to the storage bin, to be kept until ready for packing and shipping. Attention must be called to the extremely disagreeable character of hydrated lime dust. All elevators, conveyors, and bins must be designed to prevent the escape of this dust. Screw conveyors are generally used for horizontal transportation, and bucket elevators, inclosed in boxes built of two thicknesses of matched lumber with a layer of canvas between, are used for vertical transportation.

The machine in general use for packing the hydrate in bags consists of a long, narrow, horizontal wooden box, in which is revolved a shaft with pins projecting from it. The hydrated lime flows from the bin into the box. The pins convey it along the box and keep it stirred up to prevent its sticking. Along the bottom of the box are several openings, which may be closed by means of a lever and which when open connect with a long muffle-shaped chute. The bag to be filled is connected to the chute and the lever is raised so that the hydrated lime flows in. The bag rests upon a scale pan, counterbalanced by a weight. When this weight of hydrate has been admitted, the scale pan drops and in so doing pulls down the lever, thus closing the opening in the box and stopping the flow of hydrated lime. The bag is so made that both of its ends appear to be closed, and resemble the bottom of an ordinary bag. In forming the ends the smaller sides are folded over first and are overlapped by the larger sides. One of the smaller sides is left unfastened and through this opening the small muffle-shaped chute is inserted. When the bag has been filled, the pressure of its contents forces the smaller side against the overlapping portions of the larger sides and thus closes the bag. When made of paper such a bag can not be opened without tearing. If cloth is used, the top is made open in the usual manner and is tied before filling. The bag is then filled through a valve in the bottom. This bag gives much less opportunity for the dust to get out than a bag which is filled while still open and which must be handled and tied after filling.—*Mineral Resources of the U. S., 1913, Part II, U. S. Geological Survey.*

A Comparison of Triple-Expansion and Turbo-Electric Engines for Ship Propulsion

A MOST interesting comparison of widely different systems of propulsion for steamships was recently made in Sweden, where two sister vessels, one driven by ordinary triple-expansion engines and the other by turbo-electric engines, were given a careful comparative test. Not only were the two vessels identical, but the same propeller screws were used on both vessels, in order to make the conditions of the trials as exactly alike as possible.

The vessels were both of 2,225 tons displacement, and designed for a speed of 11 knots with the development of 900 indicated horse-power. Of course, the coal consumption was the important point to be determined; and in these trials it was guaranteed that the turbo-electrically equipped vessel should show a saving of 30 per cent over the triple-expansion engines. This guarantee was fulfilled, for the turbo-electric power plant showed an economy of 35 per cent, the consumption being 0.4 kilo per indicated horse-power, the engines developing 975 horse-power, and driving the vessel at an average speed of 11.88 miles per hour. These trials are of particular interest, as it is very seldom that such comparative tests can be made under so nearly identical conditions.

A Home-Made Wireless Photo-Recording Set*

The Principles Involved, and Practical Details of Construction

No more does the amateur wireless man's aerial hum tunefully in the breeze. But it would surely be unwise entirely to neglect this fascinating hobby; and much may be done in the way of completing our stations in anticipation of the great day when peace shall be declared, and our apparatus, we trust, duly returned. Therefore it may be of interest to have described a fairly easy and inexpensive means whereby automatic records can be taken of wireless signals from all the more powerful stations. The method involves no Einthoven galvanometer or similar delicate instrument, and the principal part can, in fact, be made up in a few hours from materials to be found in every workshop or laboratory. The basis of the principle is an invention due to Prof. Lippmann—the capillary electrometer. This can be put together in a very short time, and by its aid it is at once possible to read signals by sight alone. It may be made in a variety of forms; but perhaps the most convenient for our purpose is that shown (Fig. 1). *C* is an ordinary soft-glass tube, say ¼ inch bore, bent as shown, and filled nearly to the top of the shorter limb with chemically pure mercury. On the top of this, at *D*, is poured a little 20 per cent sulphuric acid, also chemically pure (diluted with distilled

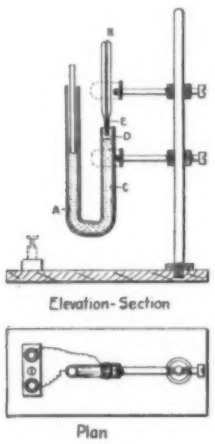


Fig. 1.

water). Dipping into the acid is a small piece of capillary tube drawn out to a very fine point at the lower end, *E*, and filled with clean mercury. It is necessary to make several of these points of different lengths and degrees of fineness, and to find by trial which gives the best results with the particular instruments in use.

The point must in any case be fine enough to prevent the mercury running through by its own weight. The finer the tube is drawn out, the higher must be the column of mercury in the capillary tube. Too fine a point is a disadvantage. The inner bore should be about as fine as a human hair. A rod of ebonite may be clipped to the longer limb, and raised or lowered in the mercury to adjust its level.

To set the instrument for use, dip the point *E* into the sulphuric acid at *D*, and force the mercury out by

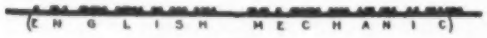


Fig. 4.

blowing with the lips through the capillary (don't swallow much, or subsequent experiments may not interest you). When the mercury is bubbling through the point in minute drops stop blowing. It will then be drawn back for a short distance by capillary attraction, and the sulphuric will follow it up as it retracts. Connections are made to the mercury at *A* and *B* with short pieces of platinum wire, and brought to terminals.

It is not necessary to go into the theory of the instrument. The vital fact is that the most minute difference of potential created between the two masses of mercury will, by affecting the surface tension, cause the fine point at the junction of liquids at *E* to move perceptibly up or down. The direction of motion will depend upon the direction of flow of the current through the junction. So sensitive is the instrument that a motion can be observed with the aid of a low-power microscope, even when the fingers are merely laid across the terminals.

If the electrometer be connected directly between the aerial and earth it will not be affected by wireless signals, but it is interesting to watch how it indicates the varying charges on the aerial wire. It is especially active during a thunderstorm, and it is often possible by its use to predict within a few seconds when a flash of lightning will occur. As the potential rises on a charged cloud, perhaps many miles away, an opposite charge of increasing magnitude is induced on the aerial, and the little mercury column moves in sympathy a relatively very long distance up or down. Then the flash occurs, and the column falls back again with a jerk.

In order that the instrument shall respond to wireless signals, the oscillating current must first be rectified; therefore a crystal detector is put in series. Two simple circuits are given diagrammatically at Fig. 3, and the position of the electrometer, *E*, indicated in each. It is worthy of note that the telephones can be left in circuit while using the electrometer, and it is possible to listen to, say, the croaking of *FL* in the ordinary way, and, at the same time, watch through the microscope, or projected on a screen, the little column of mercury rising and falling in time to the audible signals.

In the case of Eiffel's low-frequency note, the effect of each separate spark-train can be clearly seen in the way the column moves by jerks in one direction, but falls back again smoothly after the finish of each dot or dash.

It will be obvious that, having got our column to move sufficiently, the recording of signals is now merely a matter of applying an ordinary photo-recording drum with suitable screening arrangements. Such instruments are somewhat uncommon and very expensive to buy. A simple and good one can, however, be made

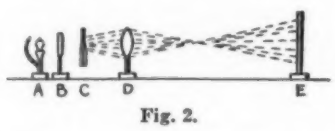


Fig. 2.

with a little care, and, in the case of those who do not possess a lathe, some slight professional aid. An instrument of this kind is always worth making, even supposing that there may be no prospect of obtaining wireless signals again for many months. It can be employed in a variety of interesting ways. For instance, by fitting a small electromagnet and pencil, an excellent record of one's Morse-sending practice may be obtained —in some cases an alarming eye-opener in the matters of spacing and speed. It may also be used to record earthquake shocks, since the working parts of a seismograph are fairly simple to make. Earthquakes, of course, do not occur every day; but, with luck, one might be caught; and, anyhow, a good old motor-'bus at half a mile would probably give quite a nice, exciting record.

A general arrangement of the recording apparatus is sketched diagrammatically at Fig. 2. *A* should be a powerful source of light, preferably with a parabolic reflector (good results can be had with a 6-8 candle-power electric lamp). *B* is a ground-glass screen to distribute and diffuse the light. In front of this is put the Lippmann electrometer, *C*. *D*, a double convex lens, and *E*, a white screen, are to be adjusted until the image of the fine electrometer tube is about four times its actual size. The image will, of course, be inverted. For clearness, it will be assumed that, when speaking of the motions of the mercury column, the image is referred to unless otherwise stated. It is a good thing to train a small microscope on to the actual capillary column in order to keep an eye on its behavior, especially while a record is being taken for the first few times. The connections at the electrometer must be reversed if necessary, so that the actual column jerks upward on the arrival of a signal (and the image downward). If the image be about a four-times magnification, and the top of the column be marked by a dot of ink on the screen when all is quiet, a downward movement of from one and a half to four millimeters will be noticed on the arrival of a signal from Eiffel. (This is for a station in the Midlands with a fairly good aerial, very moderate tuning-gear, and using an average fine capillary.) The movement during rapid signals from the same station averages about a millimeter. This is ample for controlling a light-spot. When the image is sharply focused, the screen is removed and the recording drum substituted. The method of adjusting this will be described. The recording drum itself may follow any of a variety of well-known designs. A fairly simple form is shown at Figs. 5a and 5b. The apparatus consists of a main spindle of ½ inch mild steel, 15½ inches long, bolted into a firm wooden base, and cut for 7½ inches of its upper length with a square thread 3/32 inch wide, and of the same depth, with a pitch of ¼ inch. The drum *A*, which rotates on this, is made from two 7 inch disks of $\frac{3}{16}$ inch brass sheet, cut out as shown in Fig. 5b for lightness. Round these is wrapped and soldered 1/32-inch brass foil; a piece 6 inches wide and 22 inches long will be required. (The ingenious might manage something with a suitably-sized biscuit-tin.) *B* is a spring lever carrying a nipple, which normally engages the thread. It can be released by pressure when it is desired to raise the drum quickly. *R* is merely a collar sweated on to insure smoothness in running over the large thread. The drum is rotated at one revolution per minute. This gives about the right surface speed to receive signals up to 25 words per minute with a drum of this diameter. If the length be 6 inches it will be seen that a message can be taken for 24 minutes continuously. If signals come in faster than 25 words per minute, the drum can be speeded up a little. The driving gear consists of a worm mounted on the $\frac{3}{16}$-inch shaft (*H*, Fig. 5a). (This has been drawn in full lines for clearness. It should really be shown dotted.) The worm drives the worm-wheel *E*, which is bolted to the flange *D*, carrying the upright rod *C*, which passes through and drives the drum. The worm-wheel and flange are, of course, loose on the main spindle. *M* is a piece which takes the bearing of the worm-wheel and

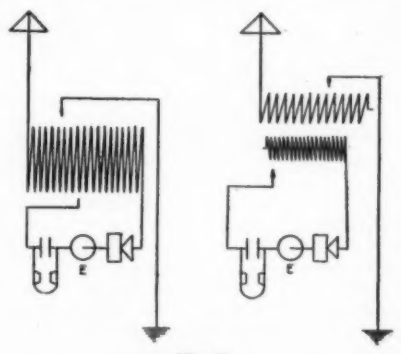


Fig. 3.

is also screwed on to the main spindle, and clamps it firmly. This thread is ordinary ½ inch Whitworth. The worm-gear should be about 25 to 1. The pulley *L* can then be driven by a slow electric motor or clockwork, and the size of *L* must depend upon the minimum smooth-running speed of the source of power used. The spindle *H* runs in brass bearings, *JJ*; and *K* is a collar which takes the thrust of the worm. The whole is inclosed in a wooden cover with a door at one side. A ½ inch square hole is cut on the vertical center line of another side and with its center 8½ inches from the

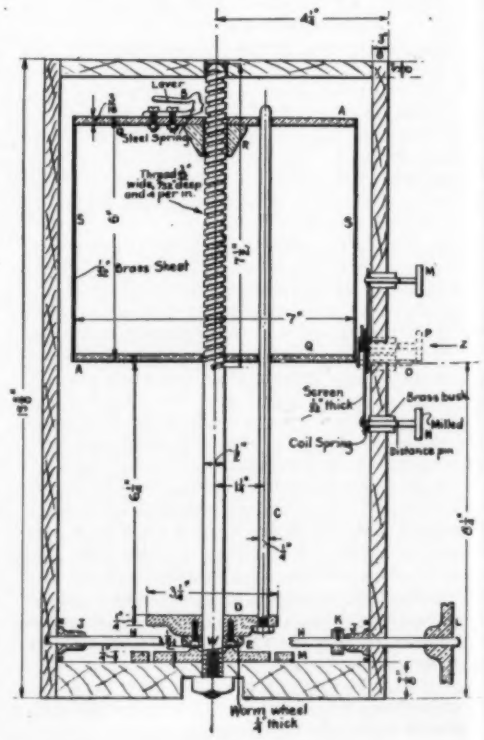


Fig. 5a.

* From the *English Mechanic*.

base. The light passes through here to the drum (*Z*, Fig. 5a). The remainder of the box must be made light-tight and carefully tested. Black velvet may be used to glue over slits in the door, etc., and the inside of the box should be painted a dead black. Behind the square hole is mounted a simple arrangement of screens (*M*, *N*, *O*, *P*, Fig. 5a). They are each soldered on to a ⅛ inch brass rod passing through a ⅜ inch bush, and are adjusted to distance and held in position by small coil springs inside and a pin through the ⅛ inch rod on the outer side.

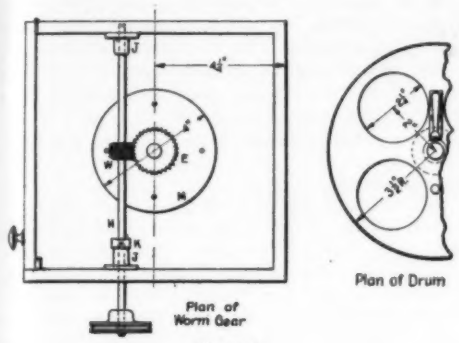


Fig. 5b.

A dimensioned plan of one of the screens is shown (Fig. 6a). All four are alike, and may be made of thin iron. Fig. 6a also shows the relative position of the screens up to the square hole, *Q*. They are numbered in order from the outside.

The screen *O* (Figs. 5a and 6a) is the inmost one, quite close to the drum, and is whitened on its outer side. It serves to focus the image upon, and is turned aside when all is ready for recording. The next in order, *P*, is a horizontal screen, which is brought down until it almost cuts off the light which shows above the top of the mercury column, when the latter is at rest. *M* and *N* are vertical screens, which cut off the superfluous light on each side.

This is best shown in Fig. 6b, which is a magnified sketch of the image of the electrometer tube, with the three cutting-off screens shown dotted. *M* and *N* have small pieces cut out of their inner sides to make the adjustment easier. The screen *O* has cross lines ruled upon it, which coincide, when it is in position, with the center lines of the square hole. To record a message,

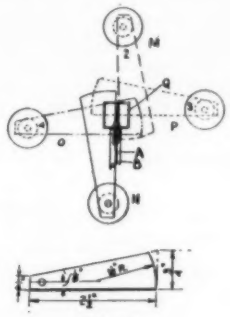


Fig. 6a.

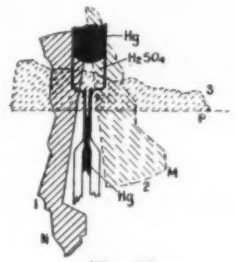


Fig. 6b.

cover the drum, in a dark room, with bromide paper. (This can be obtained in a suitable size for this apparatus from most large manufacturers, such as Messrs. Kodak, Ltd.) Wrap the paper round and secure the overlapping edges with gum. Close the instrument. Then put on the phones and tune signals to maximum loudness. See that the electrometer is behaving well; bring up the recording-box and adjust it so that the image of the end of the mercury column coincides, as nearly as possible, with the cross-lines on the screen *O*. *M* and *N* are then turned until they cut off all side light, and *P* is brought down until it does not quite cut off all the top light. If there are no atmospherics about, *P* may be brought down until it just touches the top of the column. Light will then only pass when a signal is received, and a simple dot-and-dash record will be the result. As, however, the column usually moves slightly in sympathy with natural electrostatic disturbances, it is well to allow a little margin, and the record then presents the appearance shown in Fig. 4. This is not such a nice kind of record as a simple dot-and-dash, but is quite readable. By the use of an "X-stopper" the slight unsteadiness would probably be eliminated. All being ready, the drum is started, and the screen *O* turned aside. As the drum rotates spirally past the flickering beam of light, a spiral record is made which, after development, may be read off as one reads a book.

This apparatus could also be employed to record automatically "strays" or "X's." A longer drum run at a much slower speed and having an automatic arrangement for marking the time would produce faithful records over long periods, and perhaps render unnecessary the tedious personal observations which many enthusiasts are carrying out under the direction of the British Association Radiotelegraphic Committee.

The Minimum Visual Angle*

Consequences of importance in science and art flow from the absolute size of an elementary organ of the human eye. The retina is composed of elements which are called, from their shapes, rods and cones. The rods are most abundant in the peripheral part of the retina while the central "yellow spot" of most distinct vision is composed entirely of cones. Both rods and cones are about 0.004 millimeter (0.00016 inch) in diameter. These elements, the cones especially, are the carriers of the nervous stimuli that cause visual sensations. Each cone produces only one sensation, no matter how numerous and how varied are the stimuli applied to it. In this respect the sense of sight is very like the sense of touch. The cones explore the retinal images of objects as the tactile elements of the finger tips explore real objects. The exploration is aided in one case by movements of the fingers, and in the other by movements of the eye in its socket.

Fig. 1 shows a vertical section of a human eye, looking at a point *A*. Of the light that radiates in all di-

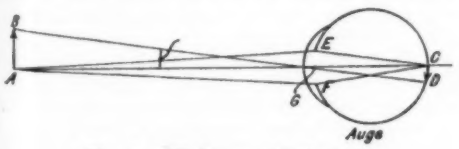


Fig. 1.—Minimum visual angle.

rections from *A*, a small conical pencil, limited by the pupil *EF*, enters the eye and is converged to a point *C* of the retina, where it excites a vertical cone and thus produces the impression of a luminous point at *A*. In like manner each point of the object *AB* forms its image at a point of the retina, and all of these points make up the retinal image *CD*, of the object *AB*. If, however, the distance *CD* is exactly equal to the diameter of a retinal cone, the eye is unable to distinguish details of the object *AB*, which it sees as a single point. The angle *BGA*, which the object then subtends at the center of the pupil *G*, is called the minimum visual angle, and the length *AB* is called a "physiological point." The average value of the minimum visual angle is one minute. Hence, the real length of the "physiological point" is 1/3,440 of its distance from the eye. For example, it is 1/287 inch at the distance of one foot and 18½ inches at the distance of one mile.

Hence, we do not see a landscape as it really is, but divide it into "physiological points," varying in size according to distance, within each of which all details are lost and all colors are blended. The tints of distant objects are affected by this fact, and the landscape painter also omits all details smaller than the physiological limit. When we view a good painting from the distance that gives the most pleasing effect we have found the correct viewpoint, both for perspective and for accordance between the "physiological points" laid down on the canvas and those of the scene as actually viewed.

The minimum visual angle plays a very important part in ophthalmology, where it forms the basis of the test letters, etc., by means of which the acuteness of vision is determined. The smaller the minimum visual angle, and therefore the smaller the "physiological point" at a given distance, the greater is the visual acuity. It has been found, however, that various capabilities of the eye must be distinguished from each other, and that the physiological processes are greatly affected by psychical influences. In particular, the ability to separate double points and double lines is much greater, in many eyes, than would be inferred from the dimensions of the retinal cones. A great deal of information in this field has been furnished by the telemeter, which is employed so extensively in the army and navy. The telemeter is a telescope with two objectives, so arranged that the upper part of a vertical object, such as a telegraph pole or a building, appears displaced relatively to the lower part. The displacement is inversely proportional to the distance of the object, and both are determined by the amount of instrumental adjustment required to bring the two parts of the object into line. If the objects are sharp and well illuminated, the probable error of the measurement corresponds to a minimum visual angle of 10 seconds, i. e., to an acuteness of vision ten times greater than the normal.

Stereoscopic or binocular vision is affected by the minimum visual angle. The stereoscopic effect is due to the relative displacement of the right-eye and left-eye images of the same object. The amount of this displacement diminishes as the distance of the object increases. When the displacement is reduced to the magnitude of the "physiological point," the stereoscopic effect vanishes. Theory and experience agree that this occurs at a distance not much greater than 300 feet, with the average acuteness of vision.

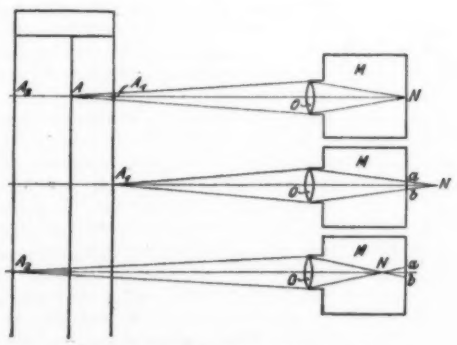


Fig. 2.—Depth of a photograph.

Experience with the Zeiss stereoscopic telemeter, however, shows that the stereoscopic sense is developed to very different degrees in different persons, and frequently to an extent corresponding to a minimum visual angle of 10 seconds.

One of the most interesting phenomena connected with the minimum visual angle is the "depth" of photographic views. If a camera is so focused that the rays emitted by a point *A* are converged to a point *N* on the ground glass screen, the rays from a near point A_1 will meet behind the screen, and the rays from a more distant point A_2 will meet in front of the screen, so that both A_1 and A_2 will be represented on the screen and in the photograph, not by points, but by "circles of diffusion" *ab* (Fig. 2). But these circles of diffusion appear to the eye as points if their diameter *ab* does not exceed the dimensions of the "physiological point" corresponding to the distance from which the photograph is viewed (e. g., 1/287 inch for a distance of one foot). In this case all objects between A_1 and A_2 appear sharp in the photograph. The distance A_1 A_2 is the "depth" of the photograph. As the "physiological points" increase in size with their distance from the eye, the admissible size of the circles of diffusion and, consequently, the "depth" of the photograph, increase with the distance from which it is viewed—a fact not sufficiently emphasized in most books on photography. Without this phenomenon of "depth" the satisfactory photographic reproduction of extended objects would be impossible.

An Unusual Accident

A flash of lightning during a thunderstorm is credited with causing an explosion in a mine shaft in South Africa which killed and injured several people. According to the report on the case, the foreman in charge of sinking the shaft had connected up his wires preparatory to a blast at the bottom of the shaft, and with his helper was being hoisted from the shaft, when the charges exploded and the two men were thrown out at the top. It is supposed that a flash of lightning during a severe thunderstorm that was raging struck the hoisting or guide ropes, by which the electricity was conducted down the shaft to some point where contact was made with the wires connected with the explosives.

Scouting With an Automobile

The more spectacular aeroplane has so monopolized public attention that few people have any idea that there is any other means of scouting in modern warfare. This is far from the case, for all the older methods are still in use; and there is a new method of employing the automobile in this work. The German scouting automobile is provided with extension ladders, similar to fire escapes, which can be raised to give the observer a wider field of view. The French, on the contrary, use their cars to operate man-lifting kites, which elevate the observer still higher.

* Abridged from Dr. Alex. Gleichen's article in *Prometheus*.

Compulsory Working of Patents*

Some American History, and Practical Results in England

By Dr. Bernard C. Hesse

THE United States Patent Act of July 13, 1832, for compulsory working of patents reads as follows:

"AN ACT CONCERNING THE ISSUING OF PATENTS TO ALIENS, FOR USEFUL DISCOVERIES AND INVENTIONS."

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the privileges granted to the aliens described in the first section of the Act, to extend the privilege of obtaining patents for useful discoveries and inventions to certain persons therein mentioned, and to enlarge and define the penalties for violating the rights of patentees, approved April seventeenth, eighteen hundred, be extended in like manner to every alien who, at the time of petitioning for a patent, shall be resident in the United States, and shall have declared his intention, according to law, to become a citizen thereof; *Provided*, That every patent granted by virtue of this Act and the privileges thereto appertaining, shall cease and determine and become absolutely void without resort to any legal process to annul or cancel the same in case of a failure on the part of any patentee, for the space of one year from the issuing thereof, to introduce into public use in the United States the invention or improvement for which the patent shall be issued; or in case the same for any period of six months after such introduction shall not continue to be publicly used and applied in the United States, or in case of failure to become a citizen of the United States, agreeably to notice given at the earliest period within which he shall be entitled to become a citizen of the United States."

This Act was repealed July 4, 1836. No such compulsory provision has since been placed on our statute books.

Precisely why this Act should have been passed and then repealed is not now determinable since a thorough search through the records of Congress does not disclose any debate nor any committee report; my information is that in those days Senate proceedings were secret and records were not kept; detailed committee reports on patents do not begin until 1837; the House records merely note introduction, the acts of reading and of passing.

GERMAN WORKING CLAUSE.

Dr. C. Wiegand, of Berlin, in a paper entitled "Compulsory Working and Compulsory Licenses," published at p. 188 of the "Transactions of the International Association for the Protection of Industrial Property," for the meeting of June, 1912, says of the German Compulsory Working Act of June 6, 1911: "Under the provisions of the previously existing law a patent could be revoked, if the invention was not worked to a sufficient degree within the country, or at any rate everything done to secure this working. Opposition to this unconditional compulsory working was made by numerous manufacturers and lawyers, and as established by the arguments in support of the law of June 6, 1911, it was shown that the system of compulsory working in itself led to the uneconomical splitting up of the source of production and that consequently the abolition of compulsory working was to be desired. The Imperial Government adopted this view in principle, but pointed out that so long as other important manufacturing countries, in which the German industries and German applicants for patents had important interests, retained their compulsory working provisions or introduced them afresh, a general abolition of compulsory working in Germany was not to be recommended. On the other hand, in all cases where another state was ready to accord the same benefit to German inventors, compulsory working should be abolished as against this state by treaty.

"There exist between Germany on the one hand and the United States, Switzerland and Italy on the other hand, treaties by which the subjects or citizens of these states, either generally or under particular conditions, are not subjected to the compulsory working provisions. The German government, which in this matter sees eye to eye with the greater part of the German industry, is anxious to proceed further on the same lines and to abolish compulsory working by treaty with other important industrial countries."

The relevant and essential text of the German working clause of June 6, 1911, is given, in translation, as follows by Dr. Wiegand (*Loc. cit.*): "If the patentee refuses to another the permission to use the invention when offered remuneration and guarantee, the right to use the invention can be accorded (compulsory license) to the other person, if the grant of this permission is demanded in the public interest. The right to use the invention can be granted with limitations and be made dependent upon conditions.

"The patent can be revoked provided state treaties do not prevent this if the invention is exclusively or mainly worked outside the German Empire or the Protectorates. The assignment of the patent to another is without effect if it has only the object of avoiding revocation.

"Before the expiration of three years after the publication of grant of the patent, no decision can be rendered against the patentee."

BRITISH WORKING CLAUSE.

In 1907 the British Parliament enacted a compulsory working clause. The following excerpts from the *Journal of the Royal Society of Arts* for 1908 and onward show how the effects of that enactment were regarded.

Vol. 56, p. 143 (Jan. 3, 1908): "The new patent law requiring the production of patented articles in English works is having the anticipated effect in bringing German color manufacturers to this country."

Vol. 56, pp. 283-4 (Jan. 31, 1908): "It is seldom that an Act of Parliament has such an immediate and beneficial effect as that which seems likely to follow upon the coming into operation of the New Patent Act. Many foreign patentees are already negotiating with British manufacturers to carry out in the United Kingdom their British patents. Others have taken land for the purpose of erecting works in order themselves to work their British manufacturers. . . .

"A well-known American company which holds British patents for the manufacture of safety razors, hitherto made solely in the States, have secured land in Sheffield, and expect to employ 500 hands as soon as their works are completed. Many other foreign manufacturers holding British patents, which they have hitherto worked solely abroad, are following their example. There is not the slightest doubt, writes Mr. Ivan Levinstein, in an interesting letter directing attention to what the new Act has already brought about, that the advent of these foreign manufacturers will mean additional employment for workers—the operative classes, highly trained engineers and chemists—and give a new impetus to British enterprise. Unlike its predecessor, the new Act is clearly worded, and leaves no loopholes for escape from its salutary and much-needed provisions."

Vol. 56, pp. 924-5 (Sept. 4, 1908): "This Act, the Patents and Designs Act, became operative on August 28th. Its principal clause runs as follows: 'At any time, not less than one year after the passing of this Act, any person may apply to the Comptroller for the revocation of the patent, on the ground that the patented article or process is manufactured or carried on exclusively or mainly outside the United Kingdom.' In future, foreign manufacturers, if they wish their patents to remain valid in Great Britain, will have to make the goods they sell within the United Kingdom. Otherwise their patents may be copied or infringed at will. Germany and the United States are particularly hit by the new enactment, and they are meeting the altered conditions by (1) building factories of their own in England; (2) acquiring premises already built for the purpose of carrying on their business; (3) arranging with British manufacturers to lay down plant and co-operate in the production of the special articles which are the subject of the patent. Already some thirty foreign firms—many of them conducting operations on a large scale—have begun, or are about to begin operations in this country, most of them choosing the North of England as the scene of their operations. It is said that as a rule the foreign manufacturer is providing a factory many times larger than is really necessary for the construction of his patented article, his explanation being that he cannot run works in England on patents alone, and he intends therefore to manufacture in this country goods that have hitherto been imported ready-made. So far as can be seen at present the Act must profit British labor. It is said in some quarters that these manufacturers, at any rate the German ones, will be worked by foreign staffs, but this is not the case at present with Messrs. Meister, Lucius, and Bruening (Limited) of Germany, a company with a capital of £11,000,000, which has just erected a new chemical factory at Ellesmere Port. Here all the manufacturers are beginning to realize that foreign workers employed are English, with the exception of a few German overseers. The working of the Act will be watched with keen and anxious attention, for British competition is about to invade their own particular territory, and that there will be a fair but strenuous fight on British soil for British custom. That is not a prospect that can be viewed altogether with anxiety when the perfection of German organization is remembered. The German things to be manufactured in England will be mostly aniline dyes, pottery, plant for gas making, rifles, plated goods, electrical contrivances, furnaces, sanitary appliances; the American typewriters, safety razors, phonograph records, shoes, telephones, and wire roofing."

Vol. 56, p. 952 (Sept. 18, 1908): "It is seldom that an Act of Parliament works quite as its authors and supporters hoped and expected. The Trade Marks Act is one of the most striking illustrations of this truth. It may be that the New Patents Act will be another. It may bring the foreign competitor to even closer grips than at present with our manufacturers, and it may lead the inventor to resort more frequently to the secret process. . . .

"Independent discovery is now the only risk menacing a monopoly based on secret working, and the risk of independent discovery is usually not great; it is at least much smaller than that consequent upon betrayal or accident. It is quite possible, therefore, that one of the results of the Patent and Designs Act, 1907, will be largely to increase the number of inventions worked as secret processes."

Vol. 57, p. 212 (Jan. 29, 1909): "There has been some recent correspondence in the *Times* as to the probable effect of the revocation of certain patents on the ground of their not having been worked in the United Kingdom. The section was intended to encourage British industries, and was indeed welcomed as a protectionist measure by the opponents of Free Trade. It is now urged that its probable result will be to encourage the manufacture of the patented article abroad and its importation into this country, it being improbable that manufacturers here will find it pays to produce it if the manufacture is unprotected by a patent. Thus the clause may now conscientiously be approved by Free Traders. Attention has also been drawn to the remarks made by the Comptroller, who, in delivering his judgment, expressed the opinion that it was to be general advantage that the trade should be freed and the importer enabled to obtain the foreign manufactured goods readily. This doctrine, if carried to its legitimate conclusion, would seem to justify the abolition of patents entirely, and the revocation, not of an occasional patent, but of the Statute of Monopolies itself."

Vol. 57, p. 340 (March 6, 1909): "The great advantages to this country attendant upon the passing of the Patents and Designs Act, 1907, have not, so far, been sufficiently appreciated by manufacturers and merchants in the United Kingdom."

Vol. 58, p. 473 (March 18, 1910): "The expectation that the Patents Act of three years ago would result in foreign firms acquiring land and erecting buildings in this country to a considerable extent has already been verified. The Act came into force on January 1, 1908, and since then foreign firms have acquired land in England to the value of £188,650, and they have spent £290,750 in the erection of buildings and the housing of their work-people, and a further sum of £410,972 on plant, machinery and equipment. Thus in two years the Act has caused foreign firms to spend £890,372 in this country. Mr. Farmer, of Messrs. Leopold Farmer and Sons, who has given special attention to the subject, says that the Americans, Germans, Dutchmen, Frenchmen and Swedes have taken part in this commercial invasion, and he estimates that over forty firms are represented. Among them are manufacturers of matches, electrical apparatus, chemicals, pottery, pencils, mercerized cotton goods, musical instruments, roofing felt, incandescent gas mantles and rubber goods, all compelled by the Patent Act to make their goods in this country, to buy land, build factories, employ home labor, and pay rates and taxes. The works are scattered all over the country. They are in the metropolitan area, Middlesex, Kent and Essex. In Cheshire several firms have established works on the Mersey; others are at Leicester bootmaking; other again at Warrington, Wolverhampton, in South Wales and Yorkshire. According to official figures some 8,000 people are employed as the result of the Act, mostly men, and the local authorities will benefit in the shape of rates substantially."

The accuracy and dependability of these statements

* From the *Journal of Industrial and Engineering Chemistry.*

is probably not very great. For instance, the combined capital of three German dye companies is given at 260,000,000 Marks and of two others at 160,000,000 Marks or 420,000,000 Marks for these 5 German dye companies. On June 30, 1912, the 21 German dye plants, inclusive of these 5, had a combined total capital of 146,800,000 Marks. That is, the *Journal of the Royal Society of Arts* attributes 3 times as much capital to 5 plants as all 21 had together almost 4 years later; the German dye companies have progressively increased their combined capital stock and have not decreased it.

The following tabulation shows 4 different estimates of fresh capital invested in Great Britain as a result of this Act:

	Pall Mall Gazette	London Daily Mail Nov. 5, 1909	Jour. Royal Society of Arts, 1910	London Times (a) March 23, 1911 p. 21
Land	$500,000	$585,000	$943,250	.....
Buildings	1,000,000	535,000	1,453,750	.....
Plant and equipment	1,000,000	435,000	2,054,860	.....
Totals	$2,500,000	$1,555,000	$4,451,860	$4,000,000
Number of firms	.....	.....	40+	50
Number of work-people	.....	.....	80000	7000

(a) Based upon reply to questions in the House of Commons at the close of 1909, made by the President of the Board of Trade; there are no official figures; official estimates alone are available.

In spite of much searching in Washington and New York I have been so far unable to locate any item-by-item statement for any of these lists. No doubt such lists exists, but so far they have succeeded in escaping me.

I quote from private letters to me (B. C. H.) from England by a friend of over 19 years' standing and dated February 8 and 12, 1915, after, for obvious reasons, having made certain indicated omissions and corresponding textual changes:

"Questions have been asked in Parliament once or twice, and I followed the answers with interest, but they were purposely very vague, and gave no real information, but put the effect of the working clauses as great as possible in a vague way.

"A firm of estate agents, Farmer and Company, who did do a little business in selling land or a factory to people coming over here to work patents made the most of the Act and wrote to the papers with reference to it, thereby getting a free advertisement. They published tables, showing the effect of the Act, which were grossly misleading; for instance, one factory appeared four times in the list with the nominal capital so that the capital was quadrupled. Again, the number of work-people to be employed by it was estimated at 400, and this given four times made 1,000, instead of 37. Precisely the same sort of thing was done with reference to any other factory as to which I know anything. I cannot say whether the list was more accurate about factories of which I know nothing, but in any case these lists were absolutely worthless. The way in which this factory was given four times was this: It was given at first under the proper name—Chemical Works. Then it was given as a factory to be erected by Company A, a factory to be erected by Company B, and a factory to be erected by Company C. (Note: A, B and C companies *together* erected this *one* plant.)

"The ———— factory was similarly treated. The effect of the working clauses in the last New Patent Act has been infinitesimally small from the point of view of bringing about new manufacture in this country, and the employment of labor. In no case has the Act resulted in any manufacture in the coal-tar dye industry continuing in this country after the patent has lapsed; for instance, while ———— was patented over here it was made in large quantities, yet the last English-made ———— was sold two or three months before the patent lapsed, and so it has been with everything else. It is impossible to produce any permanent results by these working clauses. Again, a number of patents have been revoked under the new Act. In no case has this resulted in the manufactures being effected in England. The inventor has lost his patent but there has been no manufacture resulting over here. . . . .

"I have now heard from London where I spent a few hours the day before yesterday, with reference to the compulsory working clauses. The Controller at the Patent Office assures me that there has been no official publication at all with reference to the effect of compulsory working. . . .

"The ———— Chemical Works bought 24 acres of land at £1,000 the acre, but they did this with the absolute conviction that five acres would be amply sufficient for a factory merely to work the patents. Indeed, with five acres the coefficient of safety was three.

"The factory of the ———— Company at ———— is similarly very much larger than is necessary for working the patents. The site covers, I believe, 25 acres. I am not sure of the exact size of the site. They use, I should estimate, three acres."

According to the *Journal of Commerce* of November 4, 1914, the Farbwerke Hoechst plant in England employed 50 or 60 workmen at that time; statements have been made by supporters of this clause that these works employed 600 workmen.

On April 1, 1914, The Imperial Industries Club of Great Britain had a real in-the-family and heart-to-heart discussion of this Act and its effects. The report of that discussion is given below with acknowledgments to The Imperial Industries Club, whose official pamphlet has provided this material.

Since this Act was passed for the benefit of Great Britain's chemical industry and particularly with the hope and expectation of creating in Great Britain a real coal-tar dye industry and has failed of its object, a careful study of this discussion at this time must appeal to every American chemist and maker of chemicals.

EXTRACT FROM A SYMPOSIUM ON COMPULSORY WORKING OF PATENTS AND DESIGNS IN ENGLAND.

SIR GEORGE CROYDON MARKS, M. P., said: When the Patent Act of 1907 was being discussed in Parliament I fought it every line in connection with the compulsory working proposals. I pointed out then that the people who were clamoring for it did not know what they were clamoring for—and by and by they would be sadly disappointed, as they have been. I pointed out that they were not aware of the difficulties that inventors had to get their inventions adopted—and I was considered to be a man who was only professionally interested in these things; but, unfortunately, since then inventors and others have found out that this wonderful Act, which was going to bring about such a large amount of extra work for them, has disappointed them, and it has not only disappointed them, but it has disappointed the public to some extent. That Act of 1907 had marvelously good points in connection with it quite outside the compulsory working and quite outside those things connected with that part of the subject that we are now discussing, but those points have been largely overlooked. It was a new charter which was given to the same people who clamored a few years ago under the idea that if they stamped every article when it came into this country with the name of the country from which it came then that would make people demand English things, if they happened to see "Germany" marked on it or "Belgium" marked on it. Those people were then known by some of us to be deluded people and working for a "Will o' the wisp." They got the "Will o' the wisp," and, they did not burn their fingers or get any light, but after they had apparently got it they looked for it, and found it was not there; but what was there all the time was a departing trade that the foreigners had captured owing to the immense advertisement that we had given them by requiring that stamp upon the goods "Made in Germany"; thus making people, when they wanted a cheap article, say: We must go to Germany for it; England cannot possibly do it.

No, gentlemen, we made a big mistake when we introduced into that Act of 1907 the compulsory working—a very big mistake, as the whole industry now recognizes.

Mr. Oliver Imray, ex-president of the Chartered Institute of Patent Agents: Gentlemen, what we have to consider is: What is a patent? A patent is a monopoly; and without the grant of a monopoly of some kind you cannot expect any capitalist, any manufacturer, to introduce a new invention into this country. He must have some sort of protection so that if he puts capital into a patent he is going to have the monopoly for a certain period. Now, gentlemen, the monopoly granted to a patentee is absolutely absurd as compared with that granted to the author of a book. Further, gentlemen, a patent can be attacked, first of all on disconformity between the provisional specification and complete specification, on novelty, either prior publication or prior user, on the question of subject matter, on the question as to whether the specification properly describes the invention—there are four or five grounds on which a patent can be attacked. Compulsory working introduces a further ground upon which to attack that patent.

Now, gentlemen, if you come to think of it, there are 100,000 patents in force, in existence, at any time you like to mention. I have taken out the statistics. I know it for a fact. There are 100,000 patents. What has been the result of the 1907 Act? To take an average, there have been five patents a year revoked on the ground of non-working. For the sake of those five patents a year, you introduce an additional clause for revocation of a patent, or for attacking the validity of it. Is it worth while doing that? I say it is distinctly not. Surely you ought to consider an inventor, and do the best you can for him! I have had thirty-five or forty years' experience of, not only the working classes of this country, but the working classes all over the world, and I say the compulsory working is a great farce, absolutely. You can always get outside of it.

Now, gentlemen, I agree that compulsory working to the general public is an absolutely ideal measure. It is supposed to introduce inventions into this country, and to encourage the employment of labor. That is true enough, but the result of compulsory working from my experience, and from the first few actions brought for revocation, was not to introduce the industry into this country, but to revoke the patent, and allow Germans and Belgians, and French people, to dump their goods in this country.

Gentlemen, I hope, if any other legislation takes place, it shall not make the compulsory working clause more drastic, but shall amend it in this sense: that before a person can apply for revocation of a patent on the ground of non-working he should in the first instance say that he has applied for a license, and it has been refused—that is a very good ground; and not only that, but that he is prepared to actually manufacture in this country if the patent be revoked.

Mr. A. J. Walter, K.C.: The motion which I apprehend we are gathered here to-night to discuss is the proposal made by the Manchester Chamber of Commerce to the effect that the Association urges upon His Majesty's Government to amend the rules under the Act of 1907 in such terms as will place the burden of proof of working in this country upon the patentee. A more mischievous resolution I have never had the opportunity of seeing.

What is the meaning of a patent? It is that reward which every state has found it necessary to institute in order to encourage invention. Various countries, Belgium and Switzerland among others, decided that they would have no monopolies. They found that invention dropped off at once, because there was no incentive to inventors to employ their inventive faculty. Compulsory working is dictated by nothing else than the desire of others to destroy the monopoly which the state has given to the man who has made the invention and to enjoy the fruits of that invention. Compulsory working has been suggested purely and simply by the desire to appropriate the brains of others, by persons who have not the intelligence to invent themselves. It is the destruction of the very right which the state has given to the man as a reward for his having exercised inventive faculties.

I have had, perhaps, more experience than anyone in this room of the class of persons who present petitions for the revocation of Letters Patent. I have known no case where petitions have been presented by persons who desired to work the invention in this country. Petitions are always presented by persons who have in some instances initiated manufacture abroad in order to come and present a petition to the courts of this country so that they may say that there is a greater working abroad than there is in this country, in order, as has been graphically and euphemistically described by an earlier speaker, that they may dump their goods in this country; and I know of no bona fide petition presented by any person in this realm for the revocation of Letters Patent for the purpose of encouraging manufacture in this country; but, on the other hand, all petitions have been presented for the purpose of encouraging manufacture abroad, and destroying manufacture in this country.

I am, to a certain extent, with the motion in the sense that a patent is essentially a territorial monopoly presented by the government of a country to an inventor who has benefited the country by making an invention for which they have granted him the patent, and who, if he is a bona fide inventor in the realm, will work that invention without any legislation of any kind or description. My experience is that if a man has an invention that is worth working there are very few commercial people who in time will not ascertain its value and assist him in working it without any legislation of any kind. If it is not worked it is for one or two reasons: either that it is valueless, and therefore had better be left alone, or else that the patent has been obtained by a person not domiciled in this country for the purpose of preventing working in this country, and manufacturing abroad, and importing into this country. I should draw a broad distinction myself in the case of inventors of other countries who take out patents in this country, not to benefit this country, but in order to dump their goods here, and prevent anybody manufacturing in this country.

What is the present position of compulsory licenses? It has been my privilege, I think, to be in every compulsory license case which has come before the courts

since the Act of 1888, and what has been my experience with regard to those? There has been no bona fide petition presented. It has always been the desire of the "have-nots" to share in the benefits of the "haves." Take the great monopolies of recent years: the Dunlop and the Welsbach, where there were huge industries introduced by reason of the patent monopoly granted. In every case the petitions presented against those companies were by persons who made fictitious improvements, not of any value whatever, and who then applied for licenses to work the monopolies of the Dunlop Company and the Welsbach Company. Is that the sort of way in which inventors are encouraged by a country to exercise invention? The conditions under which compulsory licenses are granted should be entirely altered from those which exist at present; and all those persons whom I call the "have-nots," who desire to share in the blessings of the "haves," should be by rules prevented from troubling patentees with their desire to reap where they have not sown.

Personally, I object to the whole of this grandmotherly legislation. It is grandmotherly. Commerce will look after itself, and if inventions are worth anything they will be worked, and the industrial members of the community will look after them.

I think that the whole legislation, both with regard to compulsory licenses and with regard to compulsory working, is a hindrance to trade, and a hindrance to invention, and should be abolished *in toto*.

Mr. H. A. Colefax, K.C.: We have heard a great deal lately of the common informer, and I cannot help thinking that these provisions which are in force to-day do really put into the hands of a man, who need be nothing more than a common informer, a right to come to the Patent Office and demand the revocation of the patent. Now, I think it was Mr. Reid at the outset of our proceedings to-night who suggested that these provisions had as their object to give more employment in this country. I do not think that is correct. I remember one of the very earliest cases, and I have been engaged in a good many of them, and I dare mention this case, because although the Comptroller is present, it was not his decision, but the decision of his predecessor. It was a case of this character. There was a patent here for a certain invention, and by an oversight no patent had been applied for in Germany. There was no question that the patent could have been obtained, but by an oversight it had not been applied for. The applicant for the revocation of that patent was a foreigner, who did, I believe, a commission business in the City of London; and his object in applying for revocation was not in any way to give employment in this country except to himself. But what he did seek to do by revoking the British patent was that he might be able to import a German-made machine into this country and so sell it freely.

The Right Hon. Lord Moulton of Bank, P.C., F.R.S.: So far as the legislation as it stands, about compulsory working is concerned, I am afraid I am going to use adjectives. I think it is not only mischievous, it is also idiotic. It is one of those cases which are growing to be common, where the layman rushes into legislation with little or no acquaintance with the subject on which he is legislating. Knowledge has gone so far that the layman cannot keep up with the technical knowledge of a subject, even in politics. In my opinion, it would have been impossible for any man who understood this matter to devise the present legislation.

Now, let us take one example, and remember when you are testing whether a thing is right or wrong by an example, you must never take an extreme example; you must take one which fairly represents it. Let me suppose that a man makes an invention and contents himself by taking out an English patent. The invention turns out to be of world-wide utility; it is adopted, we will say, by every civilized nation in the world; but the inventor has no rights abroad; he has rights in England only. Then comes some person and says, "Your patent is worked mainly abroad." Of course it is. Big as England is, the world outside is bigger. Then he appeals to this legislation, and claims that the patent must be revoked because it is worked mainly abroad. In this he is justified and the consequence is that an invention that is universally valuable and universally appreciated stands in the eye of the legislation of England, as it at present exists, as condemned to death, and it will be revoked unless the poor inventor can explain how it is that a useful thing is used more abroad than it is in England.

It is no use arguing about legislation of that kind. It is self-condemned. We should be wasting our time here, if we discussed whether it should or should not be altered. Accordingly, I prefer to utilize the time in considering what is the real mischief that has driven people to such extravagant and ill-judged legislation. I do not hesitate to say that the very able minister who fathered that bill and got it through the House of Commons literally saw red when the word inventor was mentioned. He looked upon this poor, harmless set of people as wolves ravening on the unhappy British public.

I have seen many inventors, and so many of them are people whose lives are almost eaten up by the idea that they are trying to nourish into usefulness and strength, and I think that if I had one of them before me, and he did not know anything about the legislation as to patents, and I told him, "You know that now they have passed a law for the compulsory working of inventions," he would have said, "Oh, thank God, that is all I want," because he would firmly believe that his idea was such that if it was only worked he would prosper. Such compulsory working of inventions would be the greatest possible boon for an inventor, but the present law as to compulsory working is well-nigh fatal to the chances of remuneration which he would otherwise have. It punishes him for want of success which is not due to his fault. I challenge anyone of those here present, whatever view he takes of this subject, to answer me this question. Did you ever know an inventor (who was not also a manufacturer) who was not eager to have his invention worked everywhere? The mischief that has stirred up people to pass this legislation is that manufacturers, not inventors, stop the use of inventions in this country. Just think of the cases. Do you think that a man who invents a new dye would not like it to be made by Mr. Levinstein as well as everybody else? But it is a different question when a great foreign firm gets it. They do not want to protect the inventor's rights. They want to protect the manufacturer's rights. The consequence is that the whole cause of the outcry is the manufacturer who wants to get a monopoly by means of the rights which we have given to the inventor as a reward for his original thought, and you never find any mischief of the kind that it is supposed we must guard against as long as the patent remains in the inventor's hands. I smile when I hear those who take the opposite side in this controversy talk about the advantage of compulsory working because it brings trade into England and gives work to our working class. Mr. Levinstein is an old friend and an old client of mine, but do you think he conducts his campaign in order to bring the Badische Anilin und Soda Fabrik into England? No, no, no. If you strip the cases of the formal language in which they are put, you will always find that the man who wants to revoke a patent is a manufacturer who wants to prevent the inventor proper from getting the return of his invention. I have said that I never knew any inventor, who kept the interest in his invention in his own hands, who was ever unwilling that it should be worked as largely as possible in every country in the world. No, the applications to revoke patents are not for the purpose of increasing the manufacture in England; they are for the purpose of increasing the importation into England. It is this which makes it so important to give to people clear ideas on the subject. As you know, it is quite possible that the specious appearance of a movement in favor of English manufacturers (and it can be clad in those words) may bring some attempt to increase the severity of the law. This can be resisted only by showing to the world, first of all, that the movement is always from the manufacturer—the inventor has no interest in limiting the use of his patent—and, secondly, that the aim of all these attempts is to increase importation into England, and not manufacture in England.

So much for the real substance of the case. What then is the true remedy? The true remedy is that you ought to protect the monopoly of every inventor who behaves reasonably and punish those only who act unreasonably. We are glad to welcome new industries to develop in our midst; but, if we try to bring that about by unjust laws, you may be perfectly certain you will do more harm than good, and ultimately you will regret it.

Mr. J. E. Evans-Jackson: On this question of compulsory working I suppose it will probably be admitted that I have possibly some small professional experience (over thirty years); but I am putting myself to-night in the position of a business man and a man representing, to some extent, the commerce of England; and I am going to ask you this question, and it is a serious one: Whether Great Britain will benefit by the fact that John Smith, an inventor of a horseshoe, the most meritorious and extremely beneficial horseshoe, and who applies for a patent in London, also applies for patents in forty foreign countries, Germany, France, Belgium, Austria, etc. Is it to the advantage of British commerce that that inventor should be compelled to erect forty factories, one in each of forty foreign countries, to make those horseshoes, or is it more to the advantage of this country that he should manufacture the whole lot here at a cheaper rate and send them abroad?

Now, what is my point there? Of course, you do not know. I am going to put it to you. We are going to compel John Schmidt, a German, who has invented a horseshoe in Berlin, and who has taken out a patent in forty countries, including Great Britain, to build a factory here to make those horseshoes. The thing is purely illustrative of the argument as to manufacturing certain articles. We compel one foreigner to manufacture in this country the quantity required for use of this country alone, while we lay ourselves open by retaliation on the part of foreign governments to be compelled to manufacture in forty countries the invention which has been thought out in this country.

Now, the point which appears to me to be essential is whether it is beneficial to secure the wages to the working class in manufacturing one foreign invention here and to lose the wages (which would otherwise be paid here) by being compelled to manufacture goods to meet the requirement of forty countries of a British invention abroad.

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